Compressed Air Magazine

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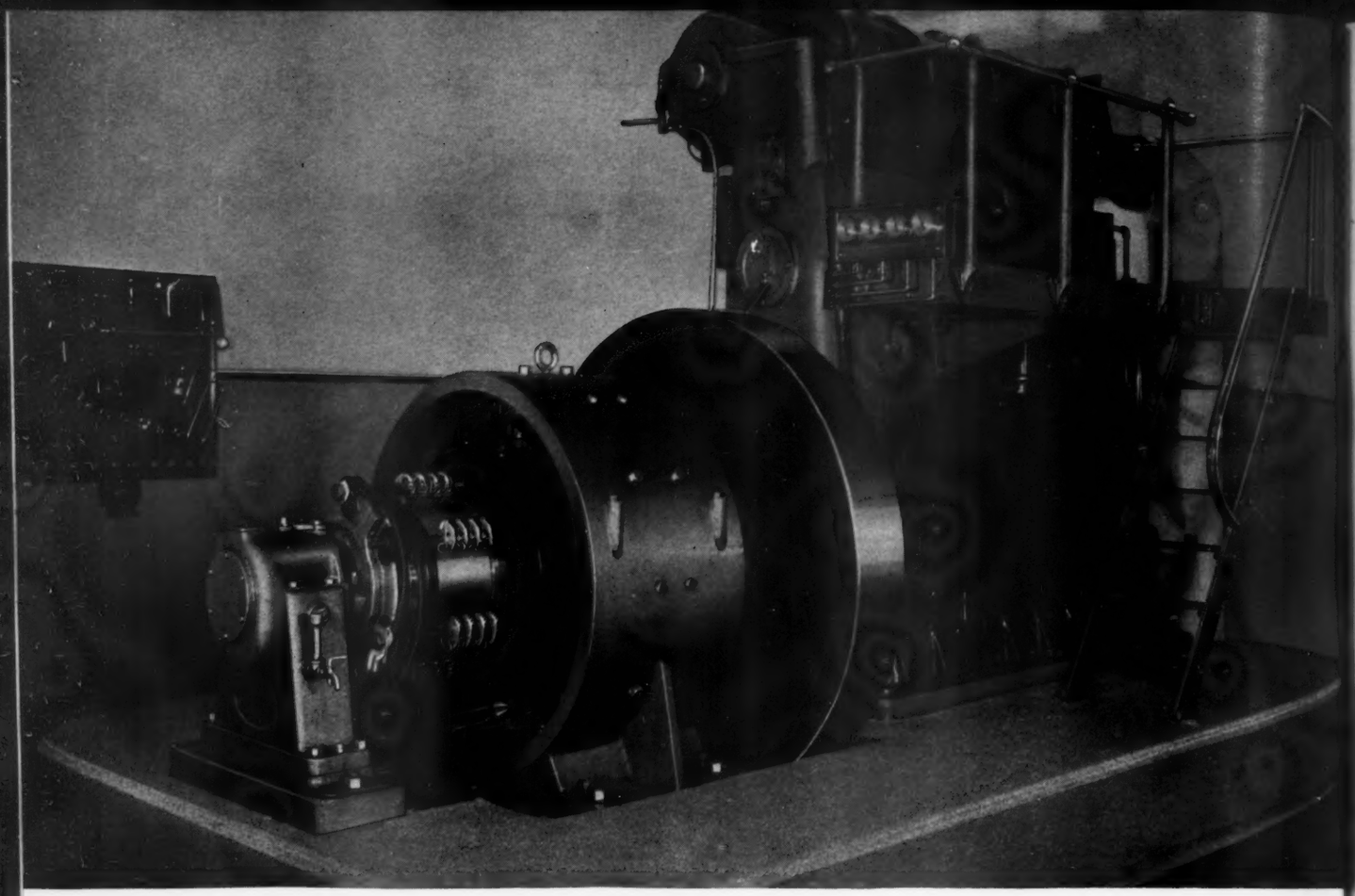
AERIAL EXPLORATIONS, INC.

A PEAK IN THE CERRO BLANCA RANGE, PERU



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Compressed Air Magazine

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EDITORIAL CONTENTS

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Historic Trinity Tower Now Rests on Rock

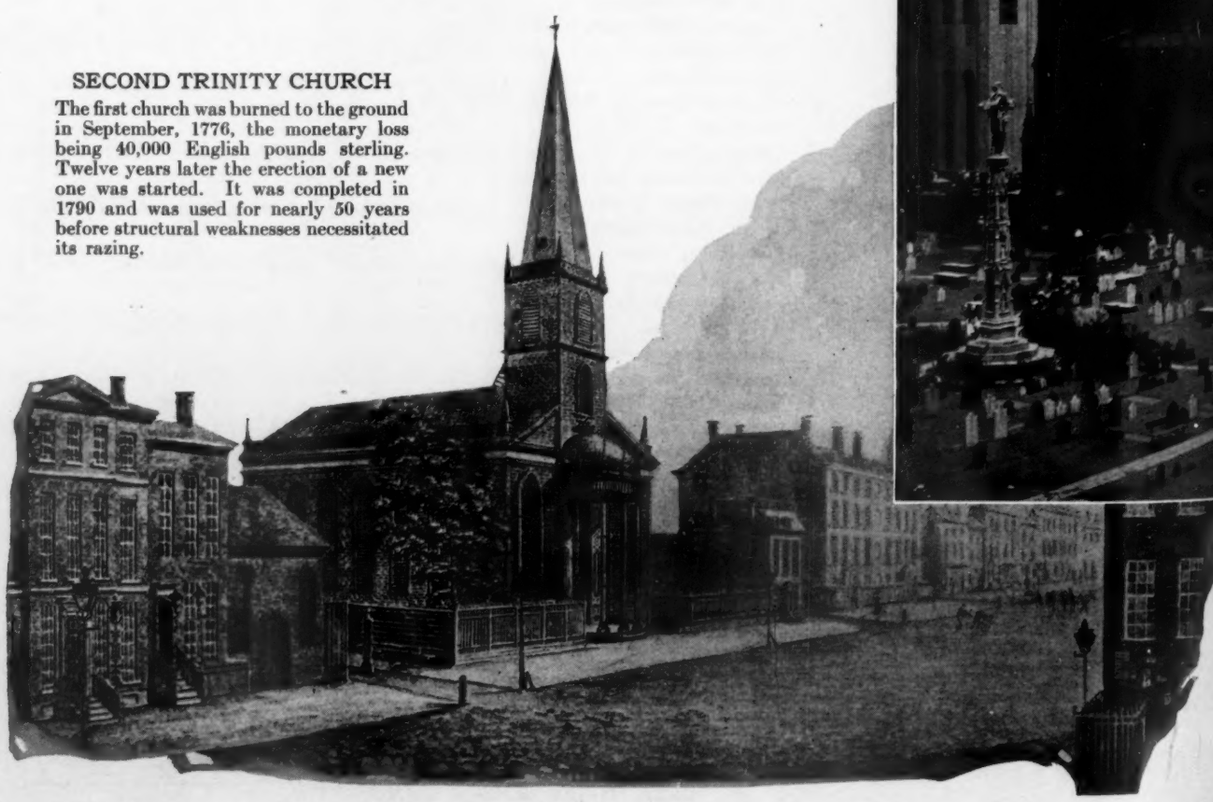
Skillful Engineering Has Safeguarded New York Church Structure Against Further Tilting

Robert G. Skerrett

HISTORIC Trinity Church, in New York City, has faced the western end of Wall Street for ninety years; but the two preceding churches of the same name on that site carried the activities of the parish back to the provincial days of Manhattan—the earlier of those structures dating in service from 1698.

During the nine decades of the present edifice, the nearby financial center of the nation has suffered many crises that have shaken America's business world to its very foundation. But all the while Trinity Church has seemed a veritable symbol of unfailing stability and has appeared physically undisturbed by the passing years. However, such has not been the fact, because subsidence of the tower at the eastern front of the structure has tilted the tip of the surmounting spire something more than 17 inches out of plumb. That movement had latterly become a continuing one, and only prompt corrective measures could be counted upon to arrest further settlement.

St. Matthew declared, in effect, that a wise man builds his house upon a rock while the foolish man sets his house upon the sand. According to that dictum, the architects of all three of the Trinity churches were deficient in wisdom, inasmuch as they reared their structures on no firmer ground than a stratum of sand and gravel. Thanks to the skillful collaboration



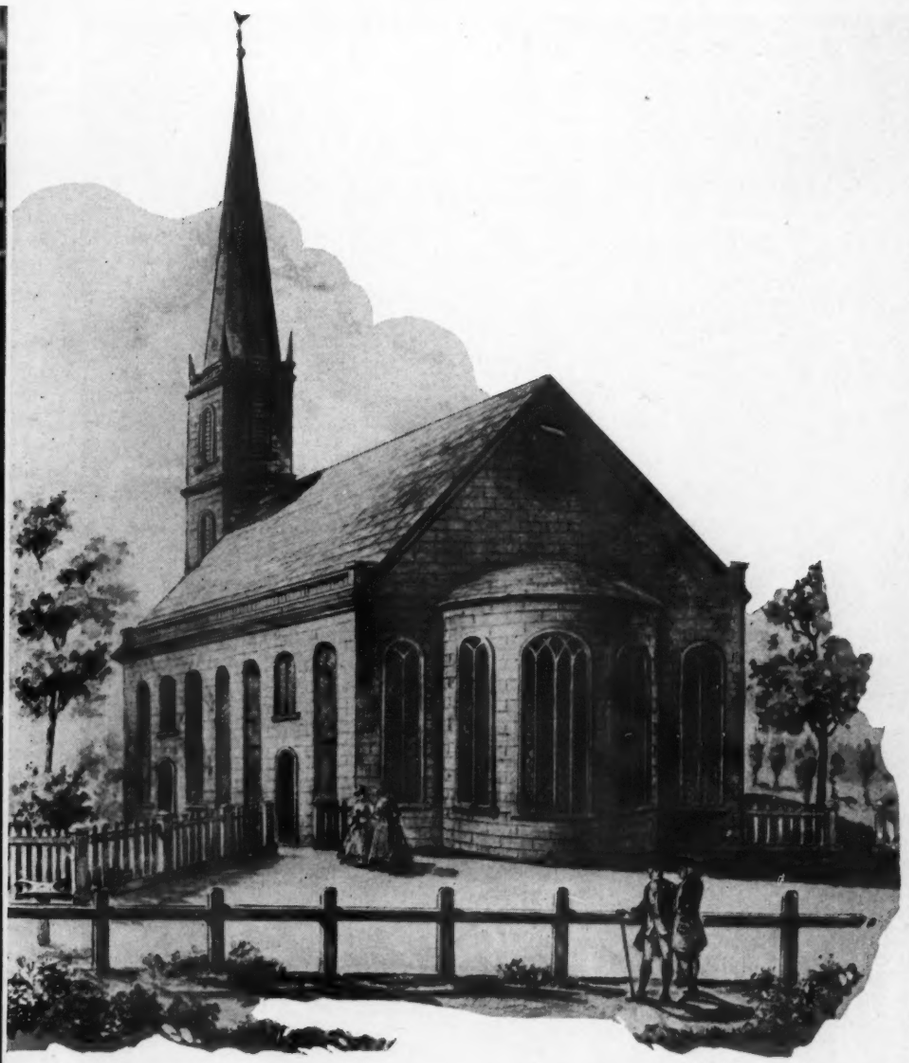
SECOND TRINITY CHURCH

The first church was burned to the ground in September, 1776, the monetary loss being 40,000 English pounds sterling. Twelve years later the erection of a new one was started. It was completed in 1790 and was used for nearly 50 years before structural weaknesses necessitated its razing.

Credit Ewing Galloway

TRINITY CHURCH TODAY

...e it is virtually surrounded by high struc-
...there are few points from which the entire
... can be photographed. This is a view
...g southeastward. The tower is shown
...t the light background of the Irving Trust
...g which stands at the southeast corner
...adway and Wall Street. The graveyard,
... flanks the church both north and south,
...es a haven of comparative quiet that is
... at noontime by workers in the nearby
...al district. Midday services are held in
...y during many weeks of the year.



FIRST TRINITY CHURCH

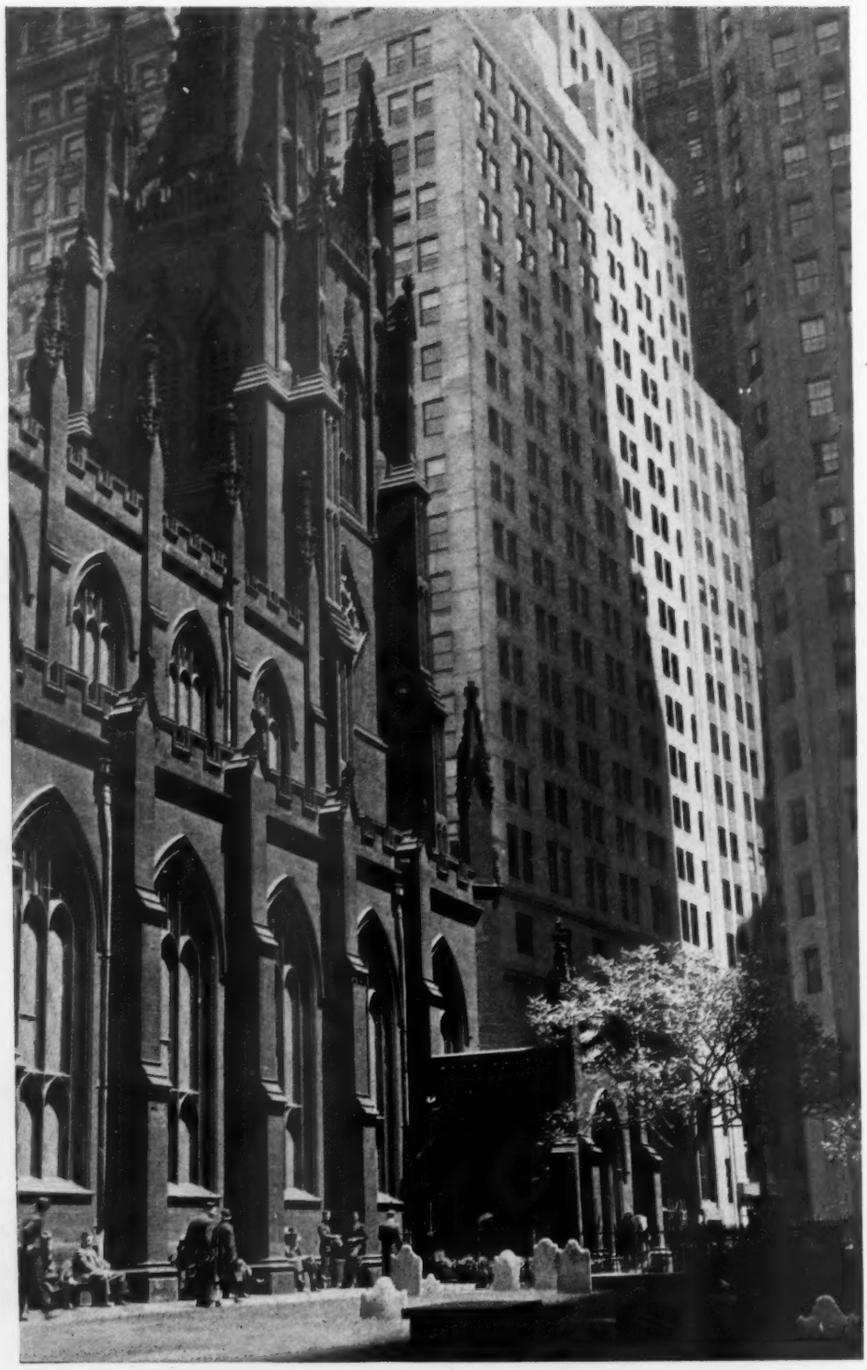
Desiring a place of their own in which to worship, the communicants of the Church of England in old Fort New York started work on a structure in 1696. The first services were held in it on March 13, 1698. It was enlarged in 1737, and this picture shows it as it then appeared. The church was a conspicuous landmark in those days and served as a guide to incoming mariners.

of the modern architect, engineer, and contractor, the tower of Trinity Church of today, in keeping with the Biblical injunction, is at last supported by the unmoving rock far below the footings of the original foundation.

Trinity Church is not just one among thousands of other houses of worship in this country: it has national significance because of its intimate identification with the stirring past of America and the nation's onward march to greatness. Within the confines of Trinity's churchyard rest the remains of Alexander Hamilton, Robert Fulton, Captain James Lawrence of the ill-fated frigate *Chesapeake*, William Bradford, the first to establish a printing press in the city, Francis Lewis, one of the signers of the Declaration of Independence, and the ashes of other persons that played a prominent part in the early history of our country.

When a British squadron appeared in the harbor in September of 1664 and compelled doughty old Peter Stuyvesant to surrender Fort New Amsterdam without firing a shot, there was within the reservation a meeting house in which the Dutch citizenry worshipped in the morning, the French residents followed at noon, while the members of the Church of England held their service some time in the afternoon. Not long after the erstwhile trading post of the West India Company became Fort New York under England's control, the local communicants of the Church of England desired a place of worship of their own, and for that purpose there was assigned a plot, just "without the wall" at a corner of the former "bouwerie" of that old Dutch commercial company.

With a grant of 450 pounds available, actual construction of the first Trinity Church was started in 1696; and when the



GRAVES AND SKYSCRAPERS

A view of the tower along the south side of the church, showing a few of the headstones in the graveyard and the tall buildings opposite on Broadway. The structure streaked with sunlight is the First National Bank Building and across from it is a corner of the Irving Trust Company's building—the two skyscrapers that were partly responsible for the settlement of Trinity's tower.

undertaking was considerably advanced, a charter was signed by Governor Benjamin Fletcher that gave to the managers of the church a patent to all stray wrecks, drift whales, and whatsoever else might be driven from the high sea and lost below high-water mark and which did not have a lawful owner otherwise within the bounds and limits of His British Majesty. The managers of the church were authorized to tow ashore and then to cut up the said whales and to try out the oil and to secure the whalebone—the proceeds to be applied to the building of the church and to no other use whatsoever until that structure should be perfectly finished. But unfortunately there was a dearth of whales to be so had when most needed, even though it is recorded that during the period of the construction of Trinity Church one whale was captured in the East River and another in the Hudson River—those creatures of the deep being more venturesome in local waters than they afterwards became.

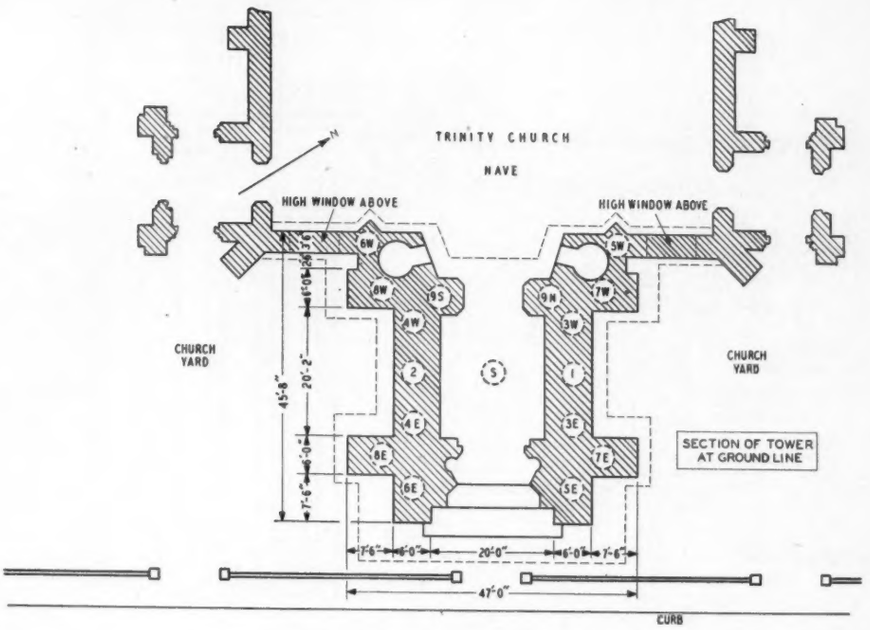
Notwithstanding a scarcity of whales and valuable wrecks, still moneys were forthcoming wherewith to construct the church; and numerous outstanding citizens contributed either funds or their services to promote the undertaking. Captain William Kidd, who was then a highly esteemed merchant and shipowner, and not the pirate he later was alleged to be, lent some of his nautical gear to help in handling and placing the building materials. Trinity Church was finished and the first services conducted in it on March 13, 1698. That edifice was 72 feet in width and 148 feet long, including the tower and chancel, and so richly ornamented within as to be quite beyond any place of its kind in the country at that time. The church was a conspicuous landmark and a guide to incoming mariners until destroyed by fire in September of 1776. It seems that that conflagration, which did widespread damage, started in a Whitehall grogshop and swept onward under the impulse of a strong southerly gale. The church corporation then sustained a loss of 40,000 pounds.

The second Trinity Church was begun in 1788 and finished and consecrated in March, 1790. Its steeple was 200 feet high and, therefore, 25 feet higher than the spire of the earlier house of worship on the same site. Because of structural weaknesses that developed in the course of 50 years of service, the second church was razed in 1838; and work upon the third Trinity Church was taken in hand in 1839 and completed and consecrated in May seven years later—the ceremony arousing deep interest in the community because of the historical background of the parish and its associations with generations of the people of the Metropolis.

Trinity Church is a brownstone structure of the so-called English Perpendicular Gothic style; and in plan is generally rectangular with a width of 79 feet and a length of 166 feet. A chapel at the northwest corner is a latter-day addition. There are projecting porches at the northeast and southeast corners that cover the side entrances at the Broadway or front end of the building. At the same end is the tower which, so far as its support is concerned, is virtually independent of the main body of the structure. It is rectangular in plan and flanked on each of its four sides by two buttresses. The center line of the tower is coincident with the longitudinal axis of the nave of the church, and the tower projects 44 feet out from the main east wall of the church; rises 134 feet 4 inches above the ground surface; and is surmounted by a spire, 140 feet 1 inch high, which is octagonal in cross section. The latter is topped with a 6-foot cross the uppermost tip of which is 280 feet 5 inches above the base of the tower. It is easy to understand how Trinity Church, before it was surrounded

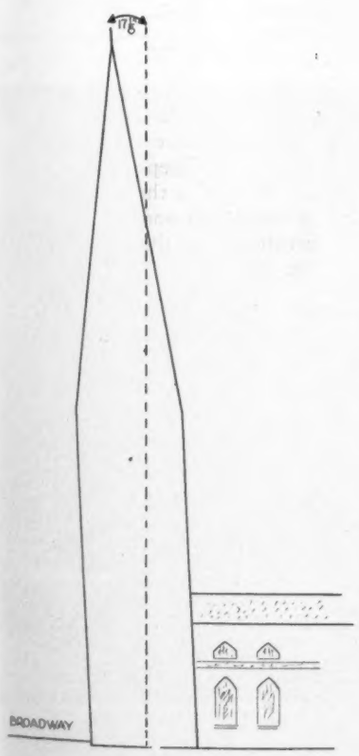
by modern skyscrapers, stood forth conspicuously from nearly every point of view. The tower and spire are also of brownstone cut with great precision and evidencing remarkably fine workmanship on the part of the masons.

The tower is set upon a foundation of hard brownstone-rubble masonry laid in cement mortar which, after 90 years, has become very hard and so bonded as to be well-nigh monolithic in character. Within the prism described by the foundation walls was placed a heavy mat of concrete, thus consolidating the foundation which extends about 12 feet below the ground surface—the footing resting upon a layer of coarse sand and gravel approximately 12 feet deep. Below the sand and gravel, reaching down to ground-water level 22 feet beneath the lower edge of the tower foundation, is a mixture of fine sand and soft moist clay; and a quicksand layer, 24 feet in vertical thickness, follows before hardpan is reached. That hardpan, which is a dense and hard aggregation of bowlders, bowlder till, sand, and gravel, is of glacial origin, and typical of the formation immediately overlying the rocky backbone of the southern part of Manhattan Island. The bowlders are not infrequently of large size, and the hardpan ranges in thickness from 12 to 15 feet under the site of Trinity Church. The bedrock is of mica schist, and the surface of that material is from 70 feet to 77 feet below the ground surface at the base of the tower.



PLAN OF UNDERPINNING

The circles show the locations of the piers which were sunk to bedrock to provide additional support for the tower. There are seventeen of these columns all told, and each consists of a succession of cylindrical sections, 4 feet 1 inch long and 42 inches in inside diameter, filled with concrete.



EXTENT OF TILT

Although it is not perceptible to the eye, Trinity Church tower is out of plumb to such an extent that its tip is 17⅛ inches eastward of where it should be. This exaggerated sketch shows how it leans toward Broadway.

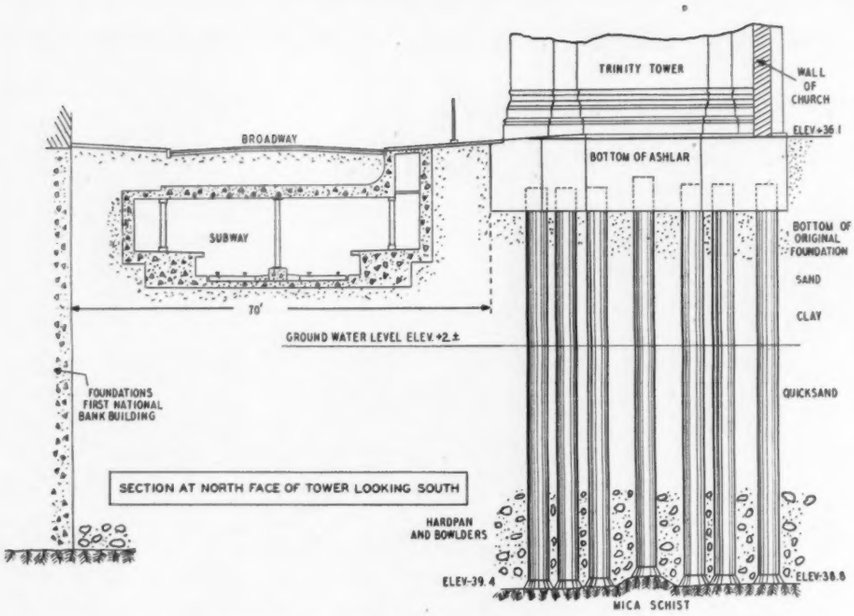
The sand-and-gravel stratum immediately underlying the foundation of the tower probably offered ample support for many years—in short, until the first subway under Broadway was excavated in 1904 with its western wall less than 10 feet away from the adjacent side of the foundation. Indeed, the bottom of that rapid-transit route was dug to a level 13 feet below the footing of the foundation!

Under the direction of Edward S. Jarrett and Daniel E. Moran, experts in their respective engineering lines, special provisions were made to support the tower foundation and to prevent any disturbance. It is possible that the subsequent support afforded by the subway structure permitted some ground movement and incidental settlement of Trinity's tower. Be this as it may, still later building operations on the two neighboring corners of Wall Street and Broadway unquestionably did effect its foundation—we refer to the erection of the Irving Trust Company's building in 1929 and the First National Bank Building started in 1932.

The foundation for each of those structures goes down to bedrock; and the substructures, where nearest to the tower foundation, are only 70 feet away and extend 56 feet below the tower's original foundation—penetrating in their descents a considerable stratum of virtually fluid and unstable soil and, perhaps, inducing an unbalancing disturbance over a fairly wide zone underground. The cracks that developed and widened afterwards in the eastern wall of the church indicated settlement in that section of the structure, and in later years the movement was accelerated. Fortunately, no cracks appeared in the masonry of the tower in the meanwhile, although subsidence was progressive. The western end of the church, adjacent to Trinity Place, settled somewhat in 1925 after the subway was constructed under that thoroughfare. As the walls at that end of the church are notably lighter than those of the tower, it was possible effectively to underpin them with piles of steel pipe that were forced down to a footing in the hardpan above bedrock by means of jacks.

In the year gone, an instrumental survey was made of the church and tower, and the precise measurements disclosed the extent of the movement of both the eastern part of the body of the church and of the tower. The survey indicated that the top of the tower leaned 7¼ inches to the north and 11⅜ inches to the east, while the top of the spire inclined 17⅛ inches to the east. Although the base of the spire was found to be 7¼ inches north of the base of the tower on which it is set, the curious fact was revealed that the top of the spire was actually 4⅛ inches to the south of the axis of the tower—in other words, the axis of the tower and the axis of the spire were no longer a continuation of the same perpendicular center line on which they were originally erected. The upper line of the plinth course of masonry at the base of the tower was ascertained to be 4 inches out of level where it had settled at the east side.

Indeed, within four months after the survey was made, the tower settled a maximum of 3/16 inch; but by that time the Corporation of Trinity Church had set in motion the



STILTS OF STEEL AND CONCRETE

This sectional sketch shows how the tower has been stopped from further settlement by resting it firmly upon solid rock. The depth of the subway and of the nearby building foundations as compared with that of the church foundation probably accounts for the recent acceleration in the rate of tilting of the tower.

work that was to arrest the subsidence of the tower and to check any further movement at that end of the church. The problem was not a simple one, because the underpinning decided upon had to be done in a way that would not weaken the substructure nor temporarily disturb the underlying ground and thus bring about accelerated settlement. To prevent this, it was necessary to distribute some part of the load of the tower to shoring arranged *pro tem* for that purpose.

The weight of the spire and tower structure above ground is 9,600 tons, while the underlying foundation weighs 2,300 tons. The total weight carried by a ground area of 2,500 square feet is, therefore, 11,900 tons—making an average load of about 4.8 tons on each square foot of sustaining soil. As the soil beneath the tower was virtually overloaded under the conditions, it was manifest to the experts that to correct the level of the tower by raising it would entail an unwarranted large outlay, and might cause disturbance and damage to the walls of the body of the church. There was but one cure that could be applied, and that was to carry the support for the tower right down to bedrock and thus to halt any further subsidence, which had not progressed far enough to make the tilt of the tower discernible to the casual eye.

A careful analysis of the controlling circumstances indicated that the type of underpinning to be adopted should be such as to lend itself to emplacement within the relatively small area of the existing tower foundation—should limit as far as practicable any disturbance or removal of the sustaining ground while successively extending the underpinning units downward to the rock. Accordingly, it was plain that each underpinning member had to have the smallest possible volume consistent with the required load-carrying capacity. This in turn, imposed upon the underpinning footings with a correspondingly restricted bearing area and, therefore, a foundation upon bedrock to assure the fullest measure of support.

To satisfy these conditions, the underpinning had to go down from 58 to 65 feet below the bottom of the tower foundation and, in doing so, to penetrate successively sand, quicksand, hardpan, and bowlders lying below the ground-water level. Manifestly, the work could be done only by employing pneumatic caissons; and each caisson was made just large enough to hold one man—the air pressure at any depth being slightly greater than the external hydrostatic pressure so as to prevent the inflow of water. The steel cylinder above each caisson was lengthened by the addition of short sections of steel tubing as the cylinder was forced downward with jacks that reacted against the weight of the superposed tower—the material entering the bottom of the caisson being excavated as the cutting edge of the latter penetrated deeper and deeper.

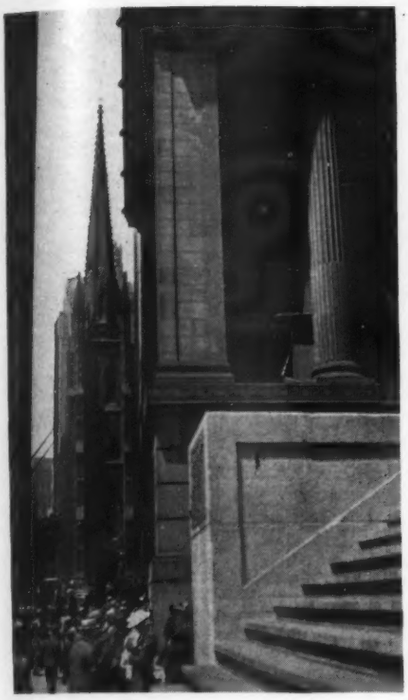
After landing on the surface of the bedrock, each cylinder was sealed at the bottom and subsequently filled to the top with concrete, forming a reinforced-concrete column that transmits its share of the load of the tower to basic rock and doing after 90 years for Trinity what was done for each of the neighboring modern buildings before any part of their structures mounted above the ground surface. There are seventeen such columns or piers now under Trinity's tower: eight beneath each side wall and one under the central concrete mat of the foundation.

Each cylinder section is 4 feet 1 inch long and made up of a single sheet of ½-inch steel rolled to form a shell having an internal diameter of 42 inches. Steel rings of the same thickness and 3 inches wide were secured, one at each end, within the shell and punched with holes for the insertion of ¾-inch bolts with which to tie successive sections together. Before use, each was tested by subjecting it to an internal pressure of 50 pounds per square inch. When a cylinder was almost in contact with the rock, a shallow but level bed of concrete was placed upon the latter, and on that bed was laid a ring, 48½ inches in outside diameter, composed of eight curved plates or segments each 1¼ inches thick and 9 inches wide. Full bearing upon that base plate was assured by driving 24 sets of steel wedges between the composite ring and the cutting edge of the caisson. With the cylinder in position and filled with concrete, it was capped with a bearing ring 49½ inches in outside diameter, 9 inches wide, and 1½ inches thick. The purpose of the ring was to put part of the superposed load directly upon the steel shell, and the remainder of the localized load on the interior column of concrete. Each cylinder or pier has an allowable load factor of 950 tons.

The two bottom sections of a cylinder constituted the working chamber, and the next two sections served as an air lock. A steel diaphragm separated those compart-

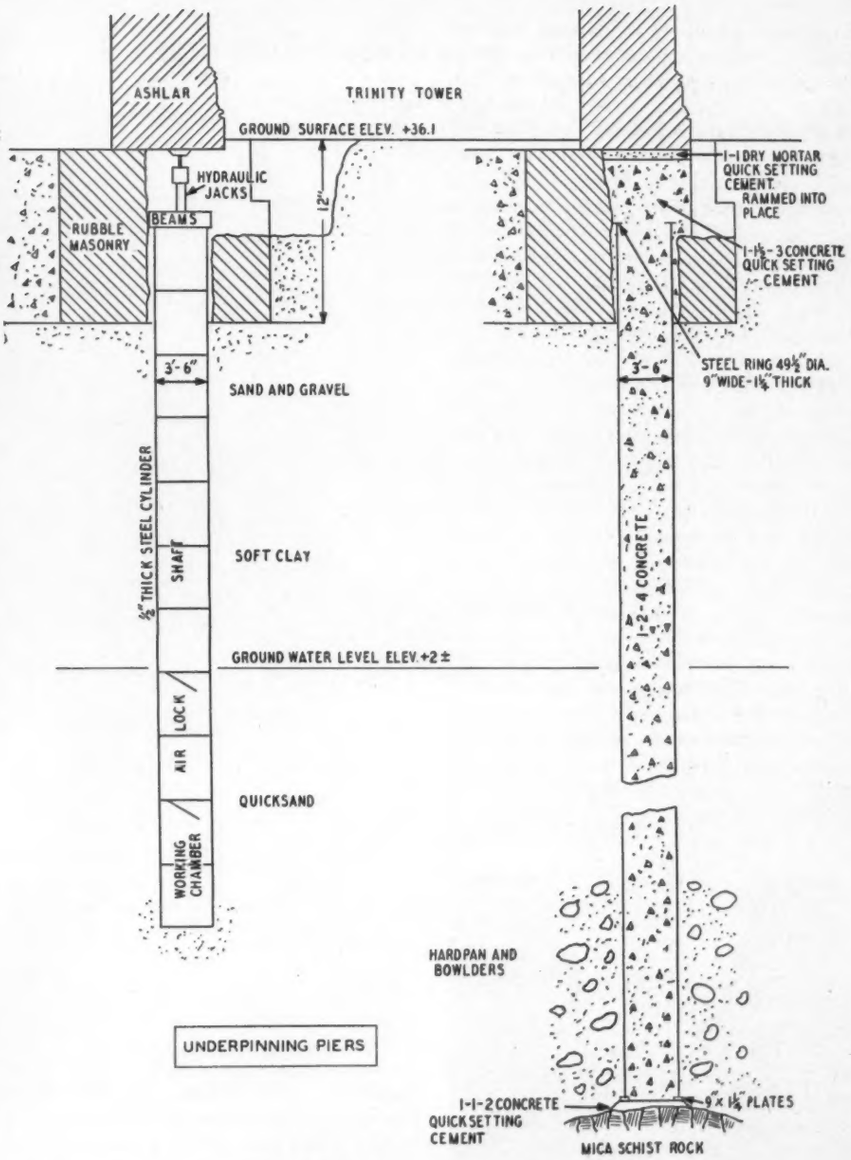
CRACKS TOLD THE STORY

Cracking of the masonry joints just above the arch of the tall window called attention to the subsidence of the eastern wall and of the adjoining tower at the front of the church.



GUARDIAN OF WALL STREET

Someone described Wall Street as a narrow thoroughfare having a church at one end and a dirty river at the other. This view was made looking westward up Wall Street from the front of the U. S. Subtreasury. Trinity Church occupies one of the most valuable pieces of ground in the world.



DETAIL OF PIER CONSTRUCTION

A finished pier is indicated at the right, while at the left is a diagram that shows how the steel cylinders were progressively sunk through unstable ground under air pressure. One man only could do the excavating in the confined space of the working chamber, and another, in the air lock, hoisted the material to the surface by the pailfuls, six at a time. Normally, it took four days to get a caisson with its surmounting cylinder down to bedrock.

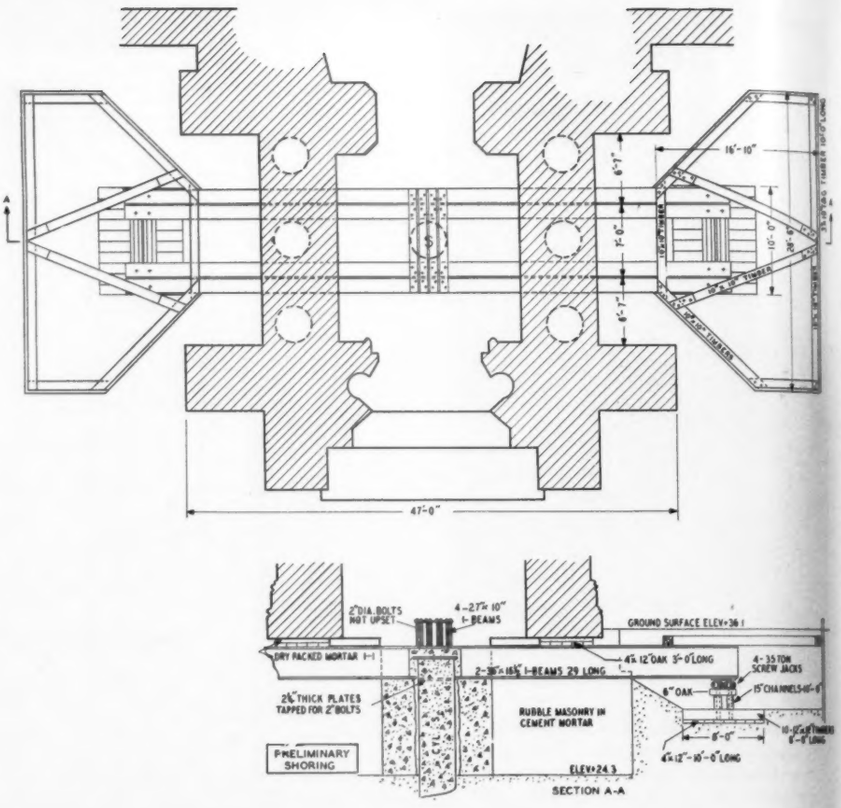
ments, and a similar diaphragm at the top of the air lock separated it from the open passage leading upward through the remainder of the cylinder. In each diaphragm there was a door that was fitted in place just before the caisson reached the groundwater level, after which further progress downward was under compressed air—piping leading to both the air lock and the caisson for pneumatic service.

Space being limited, but one man could excavate in the working chamber, while another in the air lock lifted the material by the pailful until he had a group of six, when he closed the door to the working chamber, released the air pressure in the air lock, and opened the door above him so that the six pails could be hoisted to the ground surface. At no time did the man in the working chamber excavate below the cutting edge until the caisson had penetrated hardpan; and he cleared away only the material that entered the working chamber as the jacks at the top of the cylinder, shoving upward against the foundation of the tower, pushed the cylinder downward—the next shell section being added whenever penetration was such as to permit it.

Excavating proceeded steadily and without interruption from ground water; and after each cylinder had been wedged and sealed with concrete to a depth of 6 feet, as described, the air pressure was discontinued. The maximum pressure under which the men labored was 17½ pounds per square inch; and they worked two shifts of 3¾ hours each, with a half-hour interval between shifts, every 24 hours. Compressed air at a pressure of 100 pounds was supplied to operate pneumatic tools and rock drills used in removing foundation walls and in attacking the hardpan and bowlders encountered during caisson sinking. Every cylinder was forced through the underlying ground with the aid of two hydraulic jacks, each of which had a capacity of 100 tons and was interposed between the tower foundation and beams arranged above the cylinder. The maximum friction on the surface of the cylinders was 225 pounds per square foot.

Before the cylinders were sunk, part of the tower's dead weight had to be transferred to outlying points of support to offset the effects of excavating beneath the tower while carrying the underpinning to bedrock. The shoring adopted for that purpose was in the form of four horizontal "needles" that reached from the interior center of the tower to two pits in the churchyard and north and south of the tower. The needles were below ground level and went through narrow passages cut for them through the two flanking walls of the foundation. Each needle was composed of two I-beams 3 feet in depth and 29 feet in length; and the eight I-beams were disposed in two parallel lines 4 feet apart at their adjacent sides. The passages through the substructure were 3 feet wide, high

enough to admit two I-beams, and the bottoms of the openings were more than 6 feet above the lowermost edge of the foundation. The bearing surface of the latter was therefore not reduced. At its external end each needle rested upon four screw jacks, each capable of lifting a load of 35 tons; and at their inner ends the four needles were suspended from four crosswise I-beams, 27 inches deep, by means of threaded steel bolts, 2 inches in diameter, that could be adjusted slightly to raise the needles at that point. The sustaining I-beams were carried by the first of the underpinning piers that was forced down to rock at the center of the concrete core of the tower foundation; and thus the needles were each supported at two points, with one or the other tower wall resting intermediately. A cushion of oak planking and dry-packed mortar was interposed between a needle and the underside of the lower course of the finely cut brownstone masonry to prevent damage to the stone. After taking the weight of the tower, the jacks were screwed up intermittently to compensate for a very slight settlement that occurred in the timber mats underlying the jacks; and in this manner the needles were made to carry their share of the load continuously until all but two of the underpinning piers had been completed.



TEMPORARY SHORING

During the progress of the work it was necessary to take some of the load off the tower foundation. This was done by supporting the walls on "needles" consisting of steel I-beams extending from the central pier "S" to pits outside the structure where their outer ends rested on jacks.

A PYGMY AMONG GIANTS

When the present Trinity Church was built, nearly 100 years ago, it dwarfed all other structures on the New York skyline and even served as a landmark for ships making port. Today, although the spire rises 280 feet from its base, the church is hemmed in by the mighty towers of the financial district. This picture shows the spire silhouetted against the canyon of Wall Street and looking toward the East River.

The foundation masonry is about 13 feet thick vertically; and the procedure of sinking the cylinders for the side-wall piers was as follows: From the outer side of the upper half of the foundation there was excavated in the masonry a recess 4 feet wide and about 6 feet high, and from that chamber downward to the bottom of the foundation was dug a shaft, approximately 4 feet in diameter, in which to set the first section of a cylinder and, on top of it, the two hydraulic jacks that were required to force the casing into the earth below—the jacks reacting against the masonry above. The side-wall cylinders were sunk in pairs, one underneath each wall, and this assured symmetrical support while the piers were being extended to bedrock.

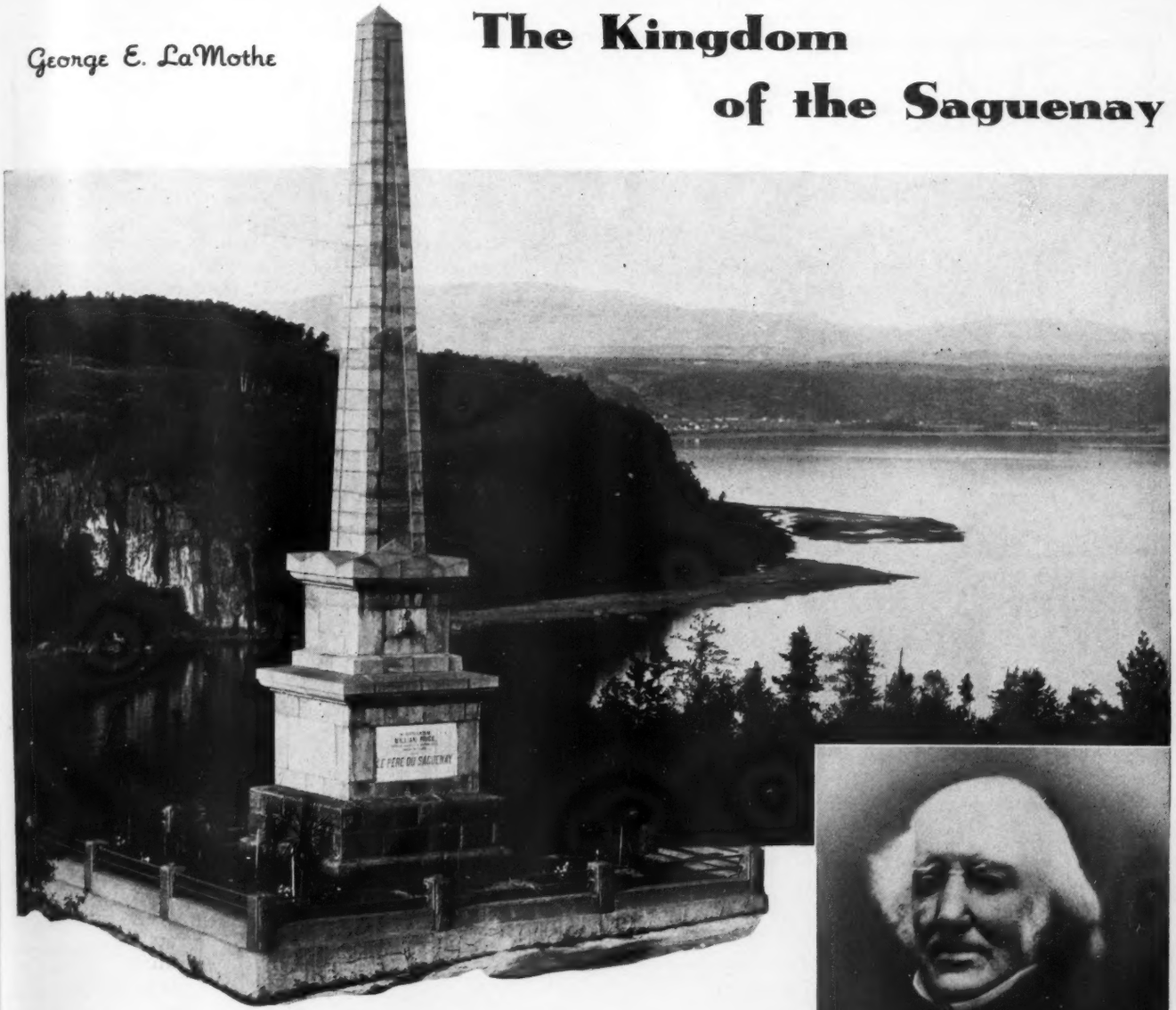
Because all sixteen of the side-wall cylinders could not be driven at one time and filled with concrete to complete them as sustaining piers, the tower continued to settle while the work was in hand. The maximum settlement that took place from the beginning to the end of the job was about 7/16 inch; and subsidence was more marked on the east side than on the west side. The sinking of a caisson with its attached long cylinder usually required four days; and the entire cost of the underpinning operations was approximately $100,000.

The plans and specifications for the work were prepared by Ralph H. Chambers, of The Foundation Company, who also supervised operations. We are indebted to him for most of the information in this article. Actual construction was done by the H. J. Deutschbein Company; and the instrumental surveys and inspection of the rock at the bottom of all caissons were made by Charles Scott Landers. Mr. Hobart Upjohn, present architect of Trinity Church, exercised general direction over the underpinning operations.

Trinity Church is the mother church of the Protestant Episcopal Diocese of New York; and the parish embraces, besides Trinity Church, seven chapels situated in different parts of the Metropolis. The parish property is today about one-third the size it was under the grant originally made by the British Government. However, the assets of the Corporation of Trinity Church now have a total value of more than $10,000,000; and these resources have made it possible for Trinity to help generously towards the support of many charitable and educational institutions and towards other parishes. Together, the three Trinity churches have served both New York and the nation during a period of 240 years; and modern engineering has given the existing structure a stability that should help to keep it standing for untold decades to come.

George E. LaMothe

The Kingdom of the Saguenay



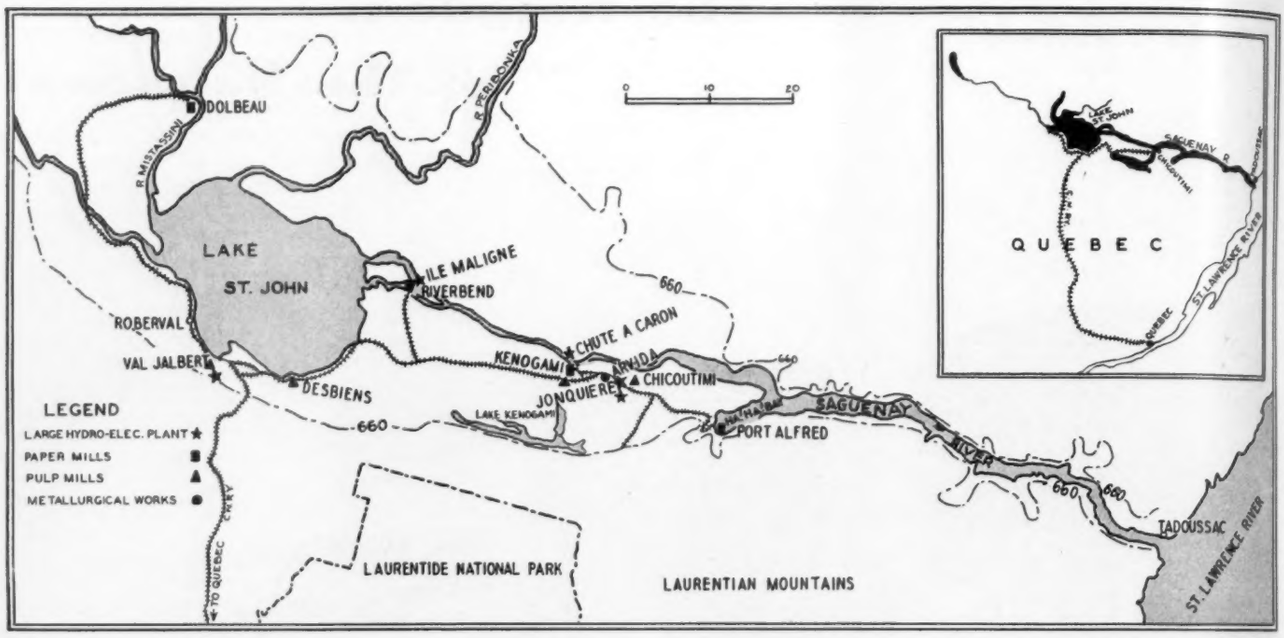
THE FATHER OF THE SAGUENAY

Although there were sporadic logging operations in the region as early as 1725, and trapping had become an established business even before then, William Price is considered to have been the Father of the Saguenay. He went there in 1810, representing an English firm seeking ship masts, and gave the forest industries their real start. He built the first sawmill in 1838, and founded the company that still carries on under the name of Price Brothers & Company Limited. The statue shown above was erected in his memory. It stands on the banks of Ha! Ha! Bay at Chicoutimi.

DID Leif Ericcson, surnamed "The Lucky," and his Norse sea rovers sail or row up the St. Lawrence River after getting lost on the Atlantic Ocean in the tenth century? And was his Vinland that part of the St. Lawrence near Quebec City where wild grapes grow instead of the coast of Nova Scotia or New England? Why not? The saga of Eric the Red never has been interpreted satisfactorily, and there is no reason why the grapes he found were not the same as those that led Jacques Cartier, five centuries later, to christen the Island of Orleans the Isle of Bacchus. If one sails the St. Lawrence below Quebec, one will discover that the Saguenay, at its mouth, closely resembles the stream described in this saga.

When Cartier, on his second visit to Canada, sailed up the St. Lawrence in 1535, he noticed a deep, swift river—*une riviere forte, profonde, et courante.* He dropped anchor and investigated. He was told it was the river that led to the Kingdom of the Saguenay. Donacona, chief of the Huron Indians at Stadacona (QueLec), gave him a very alluring description of this wonderful country. For, according to Father Charlevoix, Canada's first historian, Donacona had seen some curious things there: men that drank, but never ate; men with but one leg, one thigh, and one immense foot; and with two hands on the same arm, etc., pygmies near a great inland sea whose waters were not salted (no doubt Lake Mistassini). Part of this kingdom was reputed to be populated by men that dressed in cloth and lived in cities; and it was said that the entire region was full of gold, copper, and precious stones.

We may imagine that Cartier at first swallowed all this with a grain of salt. Donacona did his utmost to keep Cartier from continuing up the St. Lawrence, telling him that the stream was rough and impassable, and that the best way to reach the Kingdom of the Saguenay was via the Saguenay River. But Cartier did not listen, and proceeded up the St. Lawrence to Hochelaga, where the Indians gave him a grand reception and took him to the top of a high promontory from which he could get a bird's-eye view of the surrounding country. This so engaged him that he called



THE SAGUENAYAN KINGDOM

This area, about three times the size of Belgium, is potentially one of the richest in North America. Water power and wood are its chief natural resources, and their development has led to the establishment of great paper and pulp mills at various points and of a large aluminum-ore reduction works at Arvida. About 1,000 square miles of land, all below elevation 660, is arable and under cultivation. In this region live 100,000 persons, mostly of Norman blood and largely French-speaking.

the height Mount Royal, from which came the name Montreal for the city that grew at its base. From atop the mountain the Indians pointed toward the Saguenay region, and assured Cartier that there he would find metals such as those in his silver whistle, and in his chain and dagger, which were made of brass and were as shiny as gold. They also showed him some copper, which they called *caignetdaze*.

Cartier's next problem was to learn how to get to this fabulous land. The Hochelaga Indians told him it was up the Ottawa River, while Donacona and his Quebec Indians said he should go up the Saguenay. The season was late and Cartier and his men were forced to winter at Quebec, where scurvy caused many casualties among them.

Early the following spring Cartier sailed for France, taking with him Donacona and four other Indians. To say the least, King Francis I was impressed with Cartier's reports, and the Saguenay tale was perhaps instrumental in sending Cartier on the third expedition. However, the war against Spain delayed this voyage until the summer of 1541. Meanwhile, Donacona and his companions had died in France, where life was probably gaited too fast for them.

On his ensuing trip, Cartier sailed immediately up the St. Lawrence to Montreal, leaving the greater part of his crew to build a fort near Quebec. After presenting a gorgeous red coat and other gifts to the chief of the local Indian tribe, he rowed on up the river, believing he was going toward the Kingdom of the Saguenay. At the first rapids he left his boats and continued on foot. Upon coming to the second rapids (Lachine), he was told by Indians that the region he sought was much farther inland. Being short of food, he returned to Quebec. This seems to have been Cartier's last effort to find the Saguenay. Two of his nephews later tried to reach it by way of the Ottawa River, but got no nearer than their uncle did.

It requires no great stretch of the imagination to link Donacona's Kingdom of the Saguenay with the mineralized area of northwestern Quebec and northeastern Ontario. Chibougamau, the present eastern boundary of this belt, is but a short distance from the headwaters of the Saguenay River. It is on a good canoe route from Lake St. John, and numerous similar routes lead from it to the headwaters of the Ottawa River. Donacona seems to have been the first mine promotor in Canada; and had he been able to convince Cartier that the best way to reach that gold field was by the Saguenay, we can only conjecture as to the changes that might have been wrought in the history of Canada.

All the foregoing is to explain the part that the Saguenay played in the discovery of Canada. In later years, oddly enough, prospecting was carried on by the French principally in the Great Lakes region, and the Kingdom of the Saguenay was almost forgotten save for fur trading. Following in the wake of the Jesuit missionaries, fur seekers established four forts or trading posts: Tadoussac, at the mouth of the Saguenay on the St. Lawrence; Chicoutimi, at the head of navigation; Metabetchouan, on Lake St. John; and Nikauba, near Lake Chibougamau and in the hinterland, from which there were connections with the St. Maurice River posts on Lake Mistassini and Hudson's Bay. At each post there was a chapel, where the Jesuits did their utmost to evangelize the Indians.

The Jesuit father DeQuen discovered Lake St. John in 1647. There, at Desbiens Mills at the mouth of the Metabetchouan River and where the St. Raymond Paper Company today has a mill, the Jesuits some years later started a farm of more than 300 acres. This became prosperous, and cattle that were raised there were taken through the bush to Quebec to be sold, the route being approximately that now followed by the Shawinigan transmission line which runs from the Duke-Price power plant at Isle Maligne to the City of Quebec.

The first logging in the Saguenay region was probably done in the vicinity of Chicoutimi under the direction of Le Gardeur de Tilly, and had for its object the procuring of ship masts. These operations were carried on somewhere between 1725 and 1750; and less than a century later William Price was to come to Canada for the same purpose and to become known as the "Father of the Saguenay."

Fur-trading continued to occupy a leading position all through the French regime, and many famous traders and explorers of that race—among them Jolliet, Bazire, Aubert de Lachesnai, and Father Albonel—visited the Saguenay. After the capture of Quebec by the English, in 1759, the French company operating in the district (*Les fermiers des Postes du Roi*) was succeeded by the North West Company. This was

leased for a time to one William Lampson, and was finally supplanted by the Hudson's Bay Company. The latter obtained exclusive rights to the whole of the Saguenay for fur-trading purposes and held them until 1842. Until 1828, according to Buies, the first contemporary historian of the region, the Saguenay country was known chiefly for its fur industry and was a land of fabulous tales and wild legends. The river was considered unnavigable, an idea which the fur-trading companies possibly encouraged.

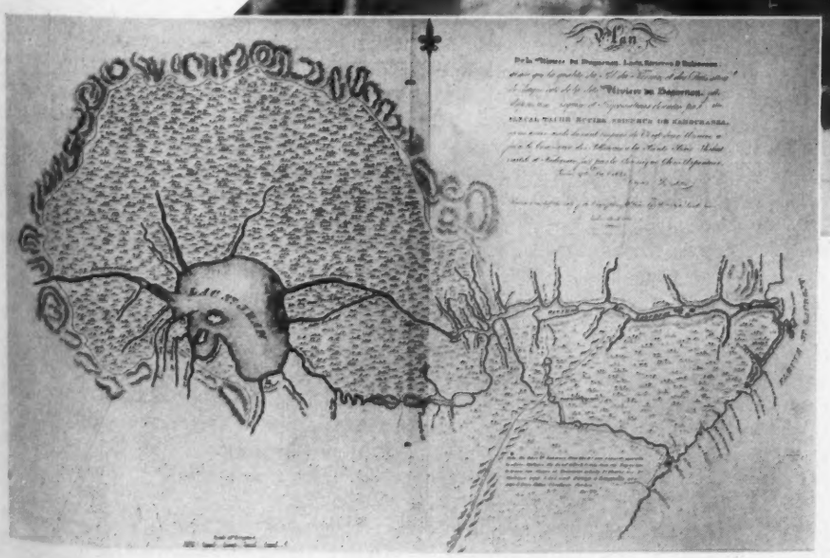
At about that time the Canadian Government sent investigators to determine the possibilities of the area for colonization. Bouchette, who later distinguished himself as an engineer, was one of those to report favorably. Squatters made various efforts at settlement, but were resisted by the Hudson's Bay Company. Tradition has it that many pitched battles took place.

The rise of lumbering dates from the arrival of Price, in 1810. He represented an English firm interested in ship masts, and evidently had a keen perception of the future the region offered for forestry. In 1838 he built the first sawmill, which was located where the salmon hatcheries at Tadoussac now stand. In the same year 21 men from Murray Bay and surrounding parishes, headed by Alexis Tremblay "Picote," having in mind the exploitation of the fine forest lands, established themselves on Ha! Ha! Bay* near the site of the present Port Alfred Mill of the Consolidated Paper Corporation and the extensive harbor of the Aluminum Company of Canada. They were fine people, and the tale of their experiences borders on the heroic. However, their capital was unequal to the demands, so in 1840 they sold their interests to Wil-

*This strange name is said to have been applied in derision by early explorers who, believing that the Saguenay would lead them to the Orient, suddenly found themselves landlocked.

WOOL FOR HOMESPUNS

In the same way that her ancestors did it in Normandy, this woman spins woollen yarn for making blankets, curtains, rugs, and other products of a fast-vanishing handicraft. These articles find a ready sale among tourists.



A CENTURY-OLD MAP

This plan of the Saguenay region was prepared in 1825 by A. Larne, and redrawn on a smaller scale two years later by William Sax, a land surveyor, who added certain features taken from sketches prepared by Father Charlevoix, Canada's first historian.

MANOIR RICHELIEU

Murray Bay, on the St. Lawrence below Quebec, is a favored vacation spot. The late President Taft was one of the many Americans to build summer homes there. For the benefit of tourists, the Canadian Steamship Lines, Ltd. maintains this large hotel where is preserved the Old World atmosphere which pervades the French-Canadian provinces.

liam Price and stayed on to work for him. Many of the descendants of those men are still there, working for Price Brothers & Company Limited, successors of William Price, as well as for other firms in the district.

The sawmill industry thrived until the end of the century, when it was supplanted by the mechanical-pulp industry, from which grew the paper-manufacturing industry of today, and by metallurgical works attracted by the inexpensive hydro-electric power that has been developed during the past decade or so on the Grand Discharge of Lake St. John.

Roughly speaking, the Saguenay drains an area of about 34,000 square miles, or about three times the size of Belgium. Probably 1,000 square miles is under cultivation, and the remainder, except water, is forest lands. From Tadoussac to the head of tidewater beyond Chicoutimi the Saguenay is bordered by great rocky hills of pre-Cambrian age. From there northward, the mountains, which reach a maximum height of 3,000 feet above sea level, lie back from the river and form a large, fertile plateau in which is situated Lake St. John.

The geological history of the Saguenay has a direct bearing upon its present industrial and agricultural pursuits. During the Tertiary period much of the area was heaved upward, and a river ran from the Lake St. John section toward the south. When ice covered the region a glacier came down across this upland, followed the river bed, and gouged it wide and deep. In places, the ice had trouble breaking through, and at those points there remain steep gradients which form the present rugged Grand and Little Discharge with their rapids and falls.

When the ice receded, the region was almost immediately plunged beneath water, and during the succeeding ages there were laid down on the bottom of this sea beds of sediments, consisting of clay, sand and gravel, and some limestone. These are the foundation of the present agricultural lands, the most fertile of which are in the zone of clay outcrops. This clay belt, dotted here and there with sand, seems to disappear completely beneath a layer of sand at an elevation that nowhere exceeds 660 feet. The good farmland ends at that line, and the forests begin there.

The Saguenay is a true fiord, that is, a valley eroded by glacial action and later inundated by the sea. Its name signifies deepness, in fact it is said that stretches of it never have been sounded. It is claimed to be the deepest river on the earth's surface.

Of the present Saguenayan population of a little more than 100,000, a great proportion is descended from the original 21 pioneers who tried to install a sawmill at Ha! Ha! Bay in 1838. Among them are persons named Warren, McNichol, Blackburn, and Harvey, who, if they know English at all, speak it with a decided French accent.

Their forebears found a fertile region, but there was no market for their produce, and all their wants could not be supplied by barter. If they had not been able to fall back on Mr. Price's logging operations, many of them would have starved, as, indeed, they came close to doing. There was no railway communication with the outer world until near the end of the last century, and the settlers were completely isolated save during five or six months of the year when navigation was open. That isolation, together with the hardships, could not do otherwise than breed a sturdy, self-reliant, and enterprising people. Ably seconded by the Roman Catholic clergy, who were mostly recruited from among their ranks, they really formed a kingdom within an empire.

The present generation was quickly absorbed by the pulp and paper industry and by the metallurgical activities at Arvida. Although primarily agriculturists, their Norman blood makes them all potential capitalists with great respect for property; and communistic ideas do not appeal to them.

They soon learned how to manage intricate paper-making machines, and the

THE CLIFFS OF THE SAGUENAY

Cape Trinity, which is named for the three successive cliffs that rise several hundred feet above the water. The white object on the lower shelf of rock at the right is a statue of the Virgin Mary. Saguenay is an Indian word meaning deep water. The river channel was gouged out by a glacier, and its bottom has never been sounded in places.

canny Scotch, who were brought over by Sir William Price when he started his first newsprint mill at Kenogami in 1913, had no better pupils than they. In the immense works of the Aluminum Company of Canada at Arvida is many a capable worker who four or five years ago did not know whether aluminum was the name of a disease or of a town. Their adaptability is proverbial, and their industry untiring. As pulpwood loggers and contractors, they are unsurpassed; and they can be found following those pursuits from Nova Scotia to the Great Lakes, returning each spring to their beloved Saguenay.

To say that their thrift is as great as that of their brothers in the old Quebec parishes would not be true. They all believe that they will be rich some day, and they like to spend their money, having unlimited confidence in the future. Even though it may take them more than a year to earn $1,000, they do not hesitate to pay that sum for an automobile, reasoning that even then they are better off than were their fathers who colonized the country. But for all their prodigality, they are sometimes hard bargain drivers. They like to dress; and a church parade, especially among the fair sex, must bring comfort to clothing manufacturers. They love to keep up with their neighbors; and that is a great thing for trade.

Birth control has never been practiced in the Saguenay. Large families are numerous, and it is the aim of every family to have in it a priest, or at least a professional who can earn a living otherwise than manually. However, manual labor is still held in high esteem, especially agriculture, which is considered the most respected of occupations. There are no illiterates among the present generation. Besides rural schools, they have financed, largely from their own resources, commercial schools and convents for girls in large centers such as Port Alfred, Bagotville, Chicoutimi, Arvida, Kenogami, Roberval, Alma, and Dolbeau. In Chicoutimi they have a college, Le Seminaire de Chicoutimi, which was founded in 1873. Besides a commercial course it gives a classical course leading to matriculation examinations admitting students to all the great universities of Canada, and also an arts course yielding a degree of the same standard as that from other Canadian universities. In conjunction with the seminary there is a school of theology and two normal schools. Most of the members of the legal and medical professions, and many businessmen, are graduates of this college. Locally educated engineers, however, are in the minority.

In the Saguenay country are four hospitals, and almost every village has its clinic. There are two weekly newspapers, one of which was a daily before the depression took its toll. Churches are numerous, as in the rest of Catholic Quebec. Chicoutimi boasts a cathedral, and is the seat of the bishop. The people are all great churchgoers. Vice and drunkenness, although not unknown, are not traits of the population. They entrust their social security to the clergy rather than to the police, the latter being practically nonexistant in the region. The Saguenayans are tolerant in their own way, and while a stranger never becomes one of them, they respect his views so long as he respects theirs. To make them work on Sunday is a great offense, and was the cause of the only serious labor trouble the Saguenay has ever known.

Rooted to the Saguenay as they are by many ties, these people constitute a dependable industrial and agricultural unit. Living costs are seemingly high for the working classes; but, paradoxical as it may sound, their frugal habits with regard to food, housing, and other necessities of life enable them to save sufficient money to buy automobiles, radios, smart clothes, and other things that give them pleasure. They encourage sports, and the Saguenay has always been a great hockey center, in fact it has contributed many members to the famous "Canadiens" that compete annually in the international league contests featuring regular games between representatives of leading American and Canadian cities. Unwise as it may seem, the Sague-

AN ANCIENT CHURCH

The first settlement in Canada was at Tadoussac, where the Saguenay flows into the St. Lawrence. It was founded by whalers who decided that trapping offered better chances for gaining riches than their own pursuit. The original village was destroyed by Indians, save for the church. The building has been repaired and rebuilt during the intervening years, but the ancient bell still peals in its tower. It is claimed to be the oldest house of worship in North America.

nay mode of living has kept the people contented and happy, which is perhaps a sufficient answer to any criticism that might be lodged against it.

So far as labor is concerned, the Saguenay is suffering from growing pains right now, especially in Alma, Jonquiere, Kenogami, and small towns of the Ha! Ha! Bay region where the rearguard of the big construction projects that were finished five years ago is now encamped and on the dole. The same situation exists in Chicoutimi, but is more intensified because of the closing of the great ground-woodpulp mills for whose products there is no profitable market today. This unemployment is the biggest problem now facing the Saguenay. It is not easy of solution, because many of those concerned are tradesmen and cannot go into the woods. Aside from this group of nonworkers, the agriculturists, bushmen, and industrial army generally are just as busy as ever.

No mines are operated in the Saguenay proper, excepting certain small enterprises that furnish limestone to the paper mills. There are some quarries, and they produce black marble of exceptional beauty and quality, as well as ordinary construction stone. Oddly enough, the cathedral that is being erected in Gaspe at the mouth of the St. Lawrence to commemorate Cartier's discovery of Canada is being built of granite from the Saguenay, near Chicoutimi.

There has been some prospecting for oil in the Utica shales that were laid down in the postglacial sea, but so far these efforts have resulted only in disappointment. Some years ago an enterprising American drilled a well near Roberval, but in the end he capped it and silently went away. During the construction of one of the smaller power plants that rest on the Trenton formation, next below the Utica, grout holes revealed the presence of natural gas, but it has never been put to commercial use. Numerous deposits of silica are scattered throughout the region, and some of this stone is being ground near Roberval. All in all, however, the mining possibilities seem to be the least interesting among the natural resources.

Most of the land suitable for agriculture is occupied and under cultivation. The relatively small population, and the remoteness of the region from large centers, have caused the farmers to go in largely for dairying and for the raising of produce that can be readily sold to lumbering camps. The arable land is given over in well-nigh equal proportions to pasturage, hay production, and the growing of grain. Oats constitute about 80 per cent of the cereal crop, which, considering the extensive western prairies of Canada, seems too great. Truck gardening and poultry-raising are unimportant, and the Saguenay imports its butter and eggs.

Land was always expensive in the Saguenay, owing to the unbounded optimism of the inhabitants. The prosperity that followed the war increased prices. Then came the vast expansion of the pulp and paper industry at Kenogami, Riverbend, Chicoutimi, Dolbeau, and Port Alfred, together with the establishment of the metallurgical works at Arvida. Many of the farmers obtained easy money by selling their land for industrial sites and for water storage, and for a while their equilibrium—financial and otherwise—was upset. Now that they have had their fling at getting rich on paper and have come to leaner days they are settling down to other ways. They were sadly harassed during the depression, and worry over mortgages only distracted them and kept them from tilling the soil. During that period the people did not know whether they were coming or going. Now they know what they want. It is not only farm credit but agricultural training. The day an agricultural school is opened in the Saguenay will be a significant one, for it will not only mark the dawn of a new era for its farmers but it will also mean less expensive living for its industrial population.

This is the first of two articles on the Saguenay region by Mr. G. E. LaMothe. The second will appear in the September issue.

CONCRETE PLACER

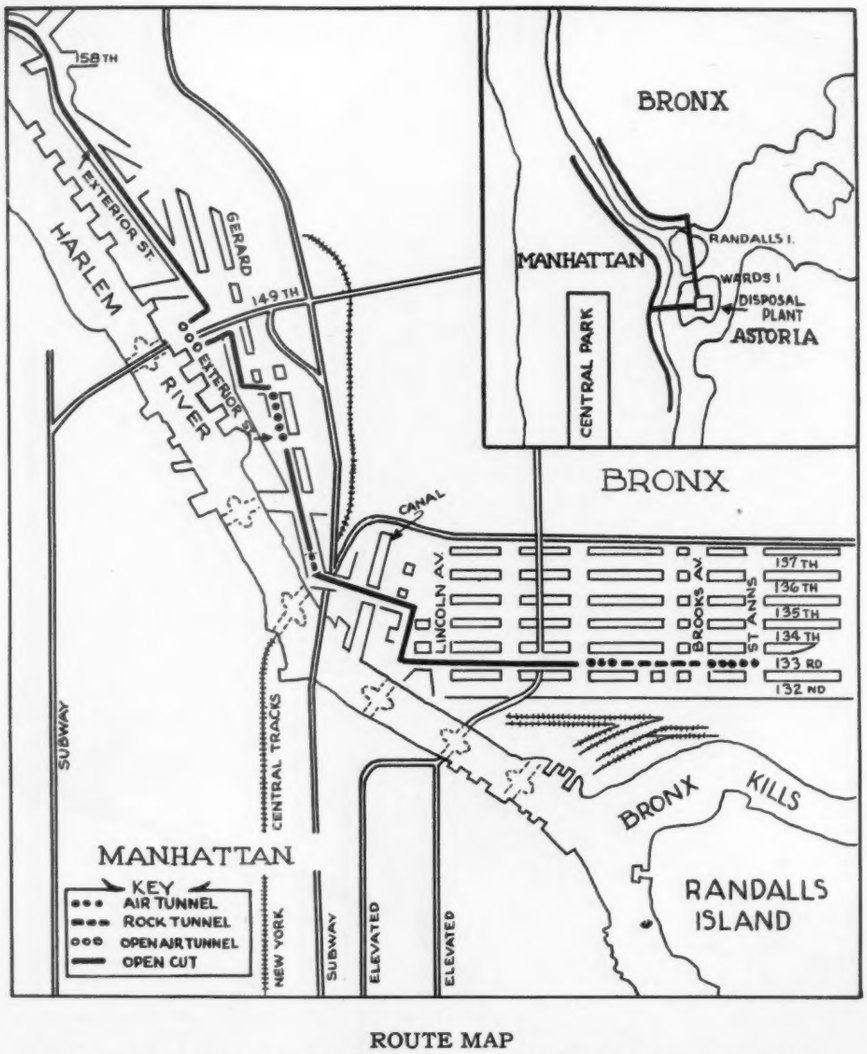
Handling half a cubic yard at a batch, this air-powered machine will deliver 30 cubic yards of concrete an hour to forms 500 feet distant. It is charged through the hopper back of the man on the left.

Building Trunk Sewers in New York City

C. H. Vivian

THE City of New York is earnestly attacking its sewage-disposal problem by entering upon a construction program that will provide facilities equal to those of any other large American city. The first sewage-disposal plant is now taking form on Wards Island, in the East River. It will serve sections of the Manhattan and Bronx boroughs, where intercepting sewers are being built to collect the sewage and to lead it to two tunnels that will connect with the Wards Island system. Eventually the program will be extended to cover every part of the five boroughs. Present plans call for dividing the city into 33 districts and for building a disposal plant in each one, although the number may be changed as the scheme progresses. The next work to be put underway will very likely be centered on the College Point area in Queens Borough, as it is desired to improve the sanitary condition of nearby Flushing Bay prior to the opening there, in 1939, of the projected World's Fair. The disposal plant will be located on Tallman's Island.

Although everyone knows that it is a huge task to maintain the cleanliness of a city the size of New York, probably few persons among those not directly concerned with it have more than a general conception of just what it involves. As summarized by Col. Thomas W. Hammond, Commissioner of the Department of Sanitation, it is the job of his department to keep 3,240 miles of paved streets clean and open to traffic; to collect and dispose of all the garbage, rubbish, ashes, and dead animals; and to treat the sewage. An average of 5,000 truck loads of refuse accumulates every day, including more than 800 dead animals. Approximately 4,000 automobiles are abandoned on the streets each year, and these the city has to remove. In the wintertime the task becomes greater in proportion to the amount of snow that falls. A 1-inch blanket of snow means that as much as 3,000,000 cubic yards has to be cleared from the street system. Beneath the streets are several thousand miles of sewer lines which collect around 1,000,000,000 gallons of sewage every 24 hours. In carrying on its varied work, the Department of Sanitation employs some 14,000 persons and spends about $28,000,000 annually. It operates and maintains 3,000 motorized vehicles, 71 scows, tugs, and other vessels, as well as 54 garages, 241 section stations,



ROUTE MAP

On the larger map is traced the course of the sewer described in this article, and the accompanying key indicates where the various construction methods were employed. The small inset map shows the relation of the Bronx and Manhattan intercepting sewers to the new disposal plant on Wards Island, with which they will be connected by two deep-level tunnels.

4 machine shops, 22 incinerators, and 15 sewage screening plants.

It has been recognized for many years that there was urgent need for better sewage-disposal facilities. With no other treatment than settling, the sewage has been discharged into the harbor waters, with the result that they have become seriously polluted. In evidence of this is cited the disappearance of well-nigh all fish life from the inner harbor, although 35 years ago the catching of crabs, lobsters, and fish was common there, and the Hudson River was famous for its shad. Bathing in any waters near the populous sections of the city has long been discouraged by medical authorities. New York City is only partly to blame for the condition, as contiguous areas in Westchester County, New York, and in New Jersey, with an estimated population of 2,370,000 persons, also have been discharging their sewage into the harbor or into connecting waterways. It is believed, however, that the example being set by New York will influence those communities to take similar action, and it is the hope of the sanitation authorities that the harbor will, in time, be restored to its former state of cleanliness.

Numerous studies of the sewage problem have been made in the past, and various plans for coping with it have been suggested. But for the depression, the project probably would have been started five or six years ago. The difficulty of financing a program on so large a scale caused its postponement until such a time as Federal funds became available for use.

The present work is following along the lines suggested in a report made in February 1931, when three alternate plans were put forward. These differed mainly in the treatment of the sewage. One of them provided for the most complete treatment that was then considered practical, and involved an outlay of $378,000,000. The second contemplated a less complete treatment and expenditures approximating $243,000,000. The third, calling for the minimum amount of treatment that was held to be at all satisfactory, was estimated to cost $158,000,000. It is the present intention to follow the second plan as generally outlined, although changes may be made as conditions and advances in the science of sewage treatment may dictate. As originally drawn up, this scheme specified three kinds of treatment among the 33 plants that were proposed. Six of them were to use the activated-sludge process, twelve a process that would partly activate the sludge, and fifteen were to employ the sedimentation process.

In the case of all three plans, the estimated costs also covered the building in each district of the intercepting sewers and other structures that would be required to collect the sewage and to deliver it to the treatment plant. Detailed engineering studies of the various districts will be made as each approaches the construction stage. Thus far, the only project that has been worked out to its final form is the one that is now underway. It includes a modern, activated-sludge treatment plant on Wards Island, together with the necessary structures for collecting the sewage in the area to be served and for conducting it to the plant. The activated-sludge process produces a highly purified effluent; and equipment may possibly be installed for recovering fertilizer from the resultant sludge.

In its initial form, the Wards Island plant will be capable of handling 180,000,000 gallons of sewage a day and will take care of the needs of a population of 1,300,000 people. The territory on which it will draw embraces the eastern and central sections of Manhattan Borough above 73rd Street, and the southern and western parts of Bronx Borough. Intercepting sewers are being built along the eastern boundary of the Manhattan area and along the southern limit of the Bronx. These will serve as trunk gathering lines and will collect the sewage from the network of sewers in that district.

Two tunnels, one leading southward from the Bronx and the other eastward from Manhattan, will link the intercepting sewers with the treatment plant on Wards Island. They will be circular in section and will be driven in rock. The one from the Bronx will be 10½ feet in diameter and will cross Bronx Kills, Randalls Island, and Little Hell Gate at an elevation of 150 feet below sea level. The one from Manhattan will extend beneath the western arm of the East River at elevation —300. Vertical shafts will form the connections between the tunnel ends and the surface. The driving of the tunnels has been contracted to the George H. Flinn Corporation, which has already started work.

To provide the facilities just enumerated will call for a total expenditure estimated at $31,000,000. It is expected that within ten years the Wards Island plant will be enlarged and the intercepting sewers extended to include additional territory in the Bronx.

When this is done, the plant will have a capacity sufficient to treat 311,000,000 gallons of sewage daily and will serve an area of 10,070 acres having a population of 2,006,000 persons. The estimated cost of the complete project is $45,000,000.

The current program calls for the construction of approximately 13,000 linear feet of intercepting sewers in the Bronx, and this phase of the work is being done by the New York firm of Rodgers & Hagerty under two contracts aggregating roughly $2,750,000. They are being built of reinforced concrete and are of horseshoe section, varying in inside dimensions from 10 feet by 7 feet 6 inches to 10 feet 6 inches by 12 feet 4 inches.

The work is of more than ordinary interest because of the varied methods of excavating that are being resorted to in order to meet the different underground conditions that prevail. Although trenching from the surface predominates, there are two sections of rock tunnel, aggregating 1,300 linear feet; three sections of soft-ground tunnel, totaling 2,000 feet, that are being driven under compressed air; one 130-foot section of earth tunnel that is being advanced in open air; and a short stretch beneath a canal that calls for the services of divers to effect a crossing. Even where the digging is being done in open cuts, there are complicating circumstances, for the line runs close to the Harlem River and throughout much of the area traversed the water table is only 4 feet below the surface. Moreover, in some places the subsurface lying between the sewer line and the river consists principally of rip-rap and is, accordingly, extremely pervious. As the average depth of cut is 30 feet, virtually the entire section being removed is water-bearing. Fortunately, the contractor has been able to cope with this problem successfully by employing the well-point system of drainage.

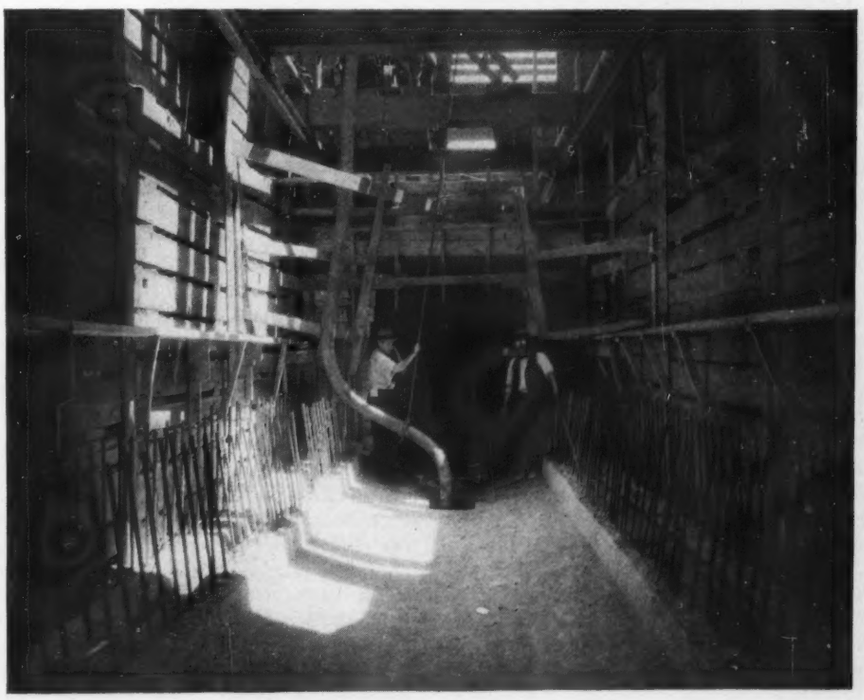
The usual method of trenching on work of this kind is to drive two parallel rows of interlocking steel sheet piling and to excavate the earth from between them. In this instance, however, the retaining structures are being formed in a different manner. They consist essentially of timber rather than of steel, and these members are arranged horizontally and not vertically. This is accomplished by first driving steel H-beams at measured intervals along each side of the trench line and far enough below the level to be excavated to give them a solid bearing—the beams being placed with the flanges parallel to the trench side. Well points are then driven on both sides and are spotted so as to fall within the zones that would be formed if parallel lines were drawn along the inner and outer faces of the respective rows of H-beams. The character of the ground and the degree to which it is saturated with water determine the spacing of the well points. This detail is in the hands of a specialist representing the Moretrench Corporation, which furnished the equipment being used. A vertical pipe extends from each well point to an 8-inch line that is supported by cross timbers near or at the top of the trench, there being one such line on each side. These are connected to a pump, and the water is thus continually withdrawn from the ground and carried to convenient disposal areas. Six pumps of various types, all gasoline-engine driven, are employed.

After the subsurface is thus dried, excavating begins. As depth is attained, timbers are set in a horizontal position by hand between each neighboring pair of H-beams, being placed behind the outside flange of the beams and also behind the vertical discharge pipes from the well points. Each H-beam serves to hold in position two timbers in each series, their ends abutting, or nearly so, behind it. When the trench has been deepened sufficiently, another course of timbers is set below the first one, and thus is started a wall that is built downward as excavating proceeds. At a point just above the level to which the top of the concrete sewer will extend, the timbers are set back of the inner or trenchward flange of the beams instead of the outer flange, and succeeding ones are carried downward on this line until the bottom of the trench is reached. This serves to provide a setback, and puts the well-point pipes behind the timbering in the lower part of the trench, thereby facilitating not only excavating but the work of erecting the forms for the pouring of concrete.

Timber cross braces that span the trench are placed between the H-beams at two levels. The lowest line of braces is sometimes as much as 16 feet above the trench bottom, and has been found to hold the flanking retaining structures satisfactorily. This type of trench support has been previously used to a limited extent elsewhere in this country, but never before in New York City.

The work of digging the trench and of constructing the sewer at the bottom of it is progressive. Ordinarily, from 300 to 600 linear feet of line is opened at a time. The excavation is carried to grade at one end, and the work of building the concrete structure proceeds from there. Meanwhile digging on the adjoining section is underway and is completed by the time the concreting gang is ready to move ahead. Several such stretches are worked on simultaneously.

The H-beams are handled during driving by a Marion No. 32 crane equipped with 60-foot leads; and three hammers—one Vulcan and two McKiernan-Terry—are available for the driving. Compressed air for this purpose and for operating rock drills and paving breakers is supplied by portable compressors, there being one model 310 Ingersoll-Rand unit with each gang. Materials are excavated by clamshell buckets operated by Lima 101 cranes, of which there are seven on the job. Clay

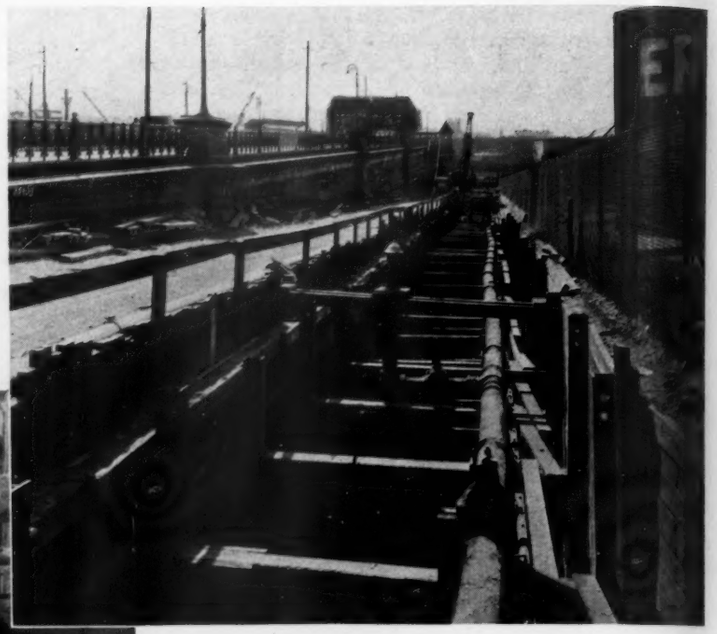


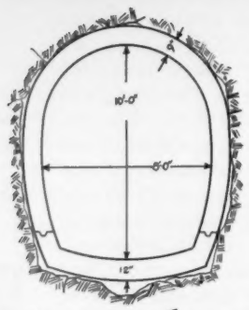
THE FLOOR OF A SEWER

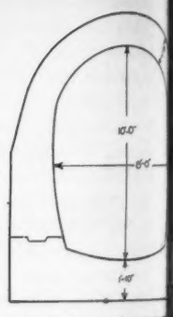
The use of the Paris sewers by Jean Valjean as a means of escape lingers in the memory of all who have read Victor Hugo's *Les Miserables*. An up-to-date Jean Valjean might even drive an automobile through the new New York sewers. At least, there is ample room to do so. Pictured here is a section of open trench, with the reinforced-concrete floor or invert poured and ready for the placing of the side walls and arch. The invert is 10 feet wide inside the curbs. The construction engineers on this job, D. Bonner and W. Kauffman, are shown on the left and right, respectively. Overhead rails on each side are for moving and suspending the arch concreting forms.

CROSSING 149TH STREET

In order to find room to insert the sewer between a bridge approach and a subway tube, it was necessary to detour several hundred feet to the edge of the Harlem River. The crossing was made at the point where the crane boom can be seen in the picture at the right. The beginning of the excavation at that point is shown below. At the spot pictured the line makes a right-angle turn to the left. The piling is supporting an older concrete sewer measuring 10 feet at the base, 5 feet at the top, and 5 feet high. The piling, which had been in water-bearing ground for 20-odd years, was in first-class condition. There was leeway here of only 2 inches in making the crossing between the top of the subway tube and the bottom of the old sewer. The Harlem River is flowing just a few feet beyond the timber retaining wall at the right. Its mean water level at this site is 19 feet above the sewer-trench grade.







10'-0"×8'-0" SEWER IN UNSUPPORTED ROCK TUNNEL

10'-0"×8'-0" SEWER IN OPEN CUT EMBA

TYPICAL TUNNEL CROSS SEC XCAVAT

is hauled to disposal dumps, while sand is stored for later use in backfilling. The trucking is done under a subcontract by J. H. Welch.

The sewer structure, of reinforced concrete, is poured in two stages. The invert, or bottom section, is placed first, after which the side walls and arch are added. Inside collapsible forms were furnished by the Koppel Industrial Car & Equipment Company, and the outside forms by the Hercules Engineering Company. Forty-foot sections are poured at a time. All concrete is purchased from the Colonial Sand & Stone Company and delivered to points of use in transit mixers. Approximately 30,000 cubic yards of concrete will be required on the contract. Details of the forms employed are shown in accompanying pictures; and a typical cross section of open-cut sewer is illustrated in one of the drawings.

One of the peculiarities of the topography of the boroughs of Manhattan and Bronx is the unsystematic manner in which rock occurs. Throughout goodly parts of those areas it is found at ground level, but here and there it dips underground, only to return at an unpredictable point. In these sections the rock surface is convoluted into alternate elevations and depressions, the latter being filled with earth. Although the numerous excavations that have been made for all kinds of structures serve as a general guide to engineers, the diggers are never certain of what they will find until they have actually probed beneath the surface. Sometimes the transition from earth to rock is very sudden, as was demonstrated in the case of this contract. For example, on 133rd Street, near Park Avenue, a vertical face of rock was encountered after the trench had been excavated in earth for several blocks. The change from soft to hard material was so sudden that an H-beam was driven to its prescribed depth at a point less than 6 inches from where this wall subsequently revealed itself. The rock continued for approximately 300 feet, and then earth was again met.

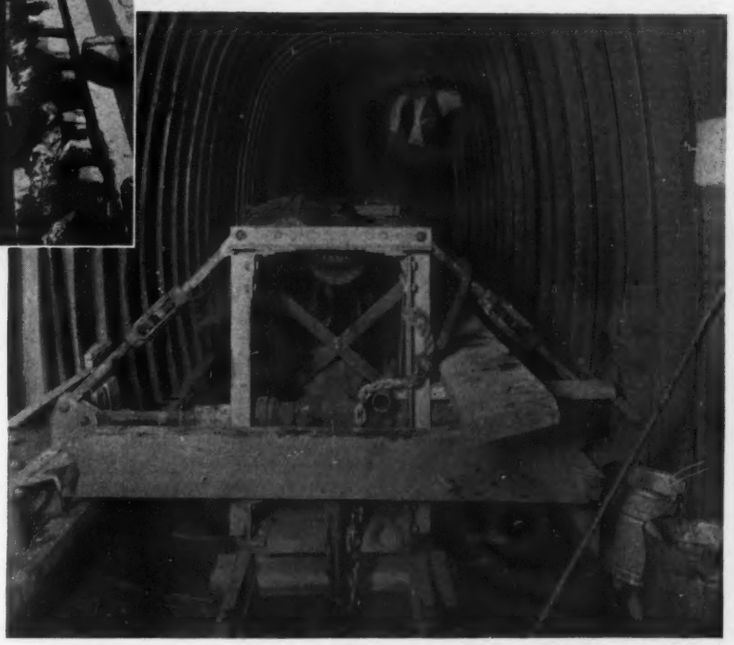
Farther east on 133rd Street was struck another rock section 1,000 feet long. On either side of it was fine-textured, pervious earth which was so unstable because of its water content that it was elected to tunnel it by the compressed-air method rather than to attempt to carry an open trench to the depth of 40 feet or more that was called for there. This stretch of the work therefore presents the unusual spectacle of two compressed-air bores connected by a rock tunnel.

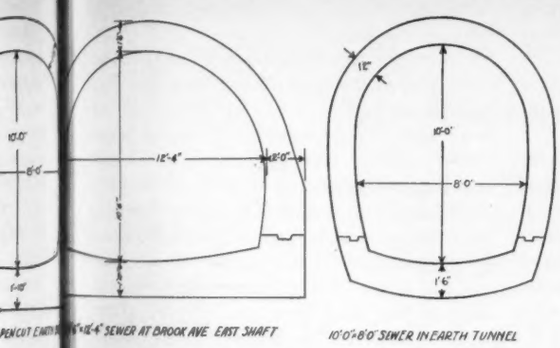
The 1,000-foot rock tunnel is of horseshoe section, 11 feet 9 inches wide and 9 feet 6 inches high. The rock penetrated is of the formation that is locally known as Fordham gneiss and was firm enough to require no timbering. It was drilled with four X-71 drifters mounted on a carriage that ran on rails. Seven feet of progress was made with each round of drilling and blasting, and the overbreak of rock outside the desired line was only 5 per cent. The normal working cycle consisted of four hours of drilling followed by two hours of mucking. Muck was loaded into Koppel 2-cubic-yard cars by a Conway shovel, "cherry pickers" at two points along the line making it possible to switch cars into position so that 5-car loaded trains could be made up at the breast. These were hauled to a shaft at one portal by storage-battery locomotive and there hoisted to the surface for dumping. Progress was as great as 128½ feet weekly.

The pressure tunnels adjoining the rock section were driven under from 12 to 14 pounds of air pressure. They were excavated 15 feet 2 inches wide and 14 feet high, and had inside dimensions after lining with concrete of 12 feet 4 inches and 10 feet 6

POURING ARCH SECTION

Shown below is the interior of a stretch of open-cut sewer after the concrete had been poured and before the removal of the forms. These steel side-wall and arch forms are supported by a carriage traveling on rails laid on the invert and are collapsible by means of turnbuckles. This section of the sewer is 10 feet wide by 8 feet high, inside. At the left is a similar section viewed from above during the pouring of concrete from a transit-mix truck via a chute and tremie. In the left foreground is a pump that draws water from the trench through the well-point system. The discharge lines extend along the walls of the trench just above the top of the concreting forms.





12'-4" SEWER AT BROOK AVE. EAST SHAFT 10'-0"×8'-0" SEWER IN EARTH TUNNEL

CAVATIONS OF VARIOUS KINDS

inches. They were advanced with a top heading and a bench 5 feet high, a plan that enabled the men to make good progress because several of them could work at the top heading while concrete was being poured in the completely excavated section immediately behind them.

As is customary, the tunnel is supported with liner plates which were placed immediately following excavating. These plates were made by the Commercial Shearing & Stamping Company and by the Truscon Steel Company, and consisted of 36x16-inch curved sheet-steel sections 3/16 inch thick and having a 2-inch lip all around to stiffen them and to provide surfaces for bolting them together. They were not erected in the form of complete rings but in horseshoe section, and were supported by jacks, extending from a central longitudinal needle beam, until a section was ready for concreting. The ends were then concreted into the invert, thus holding them securely and permitting removal of the central supports and assembly of the side-wall and arch concreting forms. The conventional type of shield was not required, the men in the heading being protected by poling plates that were made up on the job. This work was carried on under the usual regulations governing operations under compressed air in New York State. Twelve laborers and a foreman constituted a crew, and the shift was divided into two working periods of three hours each with a 2-hour rest period between them. Progress averaged between 10 and 11 feet a day, including the concreting.

All concreting in the tunnels was done pneumatically. The rock tunnel was excavated its full length and then concreted. By the time it was ready to receive its lining one of the adjacent compressed-air tunnels was underway. This made it possible to use the same equipment on both bores, the concrete shooting being alternated between them.

The pneumatic placer employed was devised by Alexander A. Cuthbertson, master mechanic on the job. It is shown in an accompanying illustration. It proved very effective in propelling concrete as far as 1,000 feet, which was the maximum distance the material had to be carried. The invert in the rock tunnel was poured in 40-foot linear sections and in about two hours per section. The side wall and arch were poured in 30-foot sections, and each of these also took about two hours. In the pressure tunnels both invert and arch were concreted in 15-foot sections, and the time required was one hour for the invert and two hours for the arch. Blaw-Knox forms were used in all the tunnels.

Two compressed-air plants were set up to supply the tunneling operations at the eastern end of the contract and, in part, were later moved to other locations, as required. One of these plants served an 800-foot section of air tunnel and an adjoining 1,000-foot section of rock tunnel. It provided 2,746 cfm. of low-pressure air by means of a 150-hp. Type XRB-1 machine and a 100-hp. Class ER-1 unit. A battery of three portable compressors furnished 100-pound air for rock drills, paving breakers and other tools, and for placing concrete. Their capacities were 500, 315, and 310 cfm., respectively. There was also a 310-cfm. portable at the shaft of the rock tunnel. At the same location was a blacksmith shop equipped with an I-R No. 50 drill-steel sharpener and a No. 26 oil furnace. Ventilating air in the rock tunnel was supplied by a Buffalo Forge Company 24-inch, motor-driven fan. The other plant served the second pressure tunnel in the same area and contained two ER-1 units and a 2-stage machine that was operated as a low-pressure compressor by dispensing

with the intercooler and by rearranging the piping. Two 310-cfm. portables were stationed at the shaft to supply high-pressure air. All these machines were of Ingersoll-Rand manufacture.

At two points along that part of the route which is being excavated in open cut, underground conditions are such as to create special construction problems. One such troublesome place was where the line would normally have crossed 149th Street at Exterior Street. The approach to the 149th Street Bridge over the Harlem River starts there, and underneath it is the Lenox Avenue line of the Interborough Rapid Transit subway which runs under the river by means of a tube. To avoid these obstructions in its path, the sewer route was detoured to within 100 feet of the river, where a right-angle turn was made to cross 149th Street and another right-angle turn to carry it back to Exterior Street. At the 149th Street crossing thus gained, the subway tube attains greater depth and the bridge approach greater elevation, thereby providing sufficient space between them to permit insertion of the sewer. However, there was little room to spare, for another structure—an old concrete sewer supported on wood piling—was already there. Measurements showed that the new sewer could be squeezed into the opening between the top of the subway tube and the bottom of the old sewer with just 2 inches leeway. At this point the sewer trench was 19 feet below the mean water level of the nearby Harlem River, but the bottom was kept virtually free from water by the well-point drainage system that was employed. The actual crossing beneath 149th Street was made by an open-air tunnel. The side walls of the bridge approach are composed of stone, are 15 feet thick, and had to be supported during the work.

INTERIOR OF COMPRESSOR PLANT

One of the two stations set up to supply low- and high-pressure air to the tunnels. In the foreground is a Type XL 500-cfm. portable compressor. Beyond it are two other portable machines and two low-pressure stationary units.

Another location that calls for special handling is at 135th Street, where the sewer must be carried beneath the Mott Haven Canal that branches out from the Harlem River. Detailed plans for this crossing have not been laid out, but it is certain that some phases of the operations will be of a subaqueous character and call for the assistance of divers.

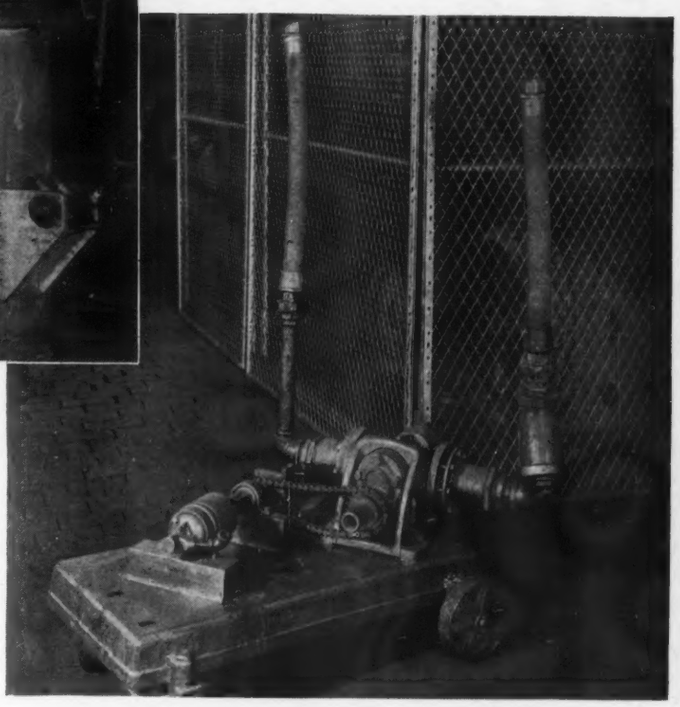
One minor, unexpected problem that was encountered injected a humorous note into the job. When the contractors started work they were surprised to find a small brick business structure on 135th Street near Park Avenue and directly in the path of the route to be followed. They were surprised because they had not noticed it when they went over the line preparatory to submitting a bid. Investigation revealed that the building had been erected during the interval between the tendering of bids and the awarding of the contract. The structure was moved to a new, nearby location, the contractors receiving compensation for the work.

The project just described is officially listed as Sections 11 and 12 of the Bronx Intercepting Sewers, the work being divided, at 135th Street, into two separate contracts. Section 11 was begun on January 1 of this year, and on July 15 was substantially 90 per cent completed. Section 12 was taken in hand on April 1, and was about 40 per cent finished on July 15. As a grant of Federal funds was received by the City of New York to carry on the sewer program, it is being prosecuted as a PWA job and is known as Federal Works Project No. 8044. The usual regulations concerning hours of work, wages, etc., are in force.

The operations are under the direct personal supervision of John J. Hagerty, head of the contracting firm. Another officer, T. J. Carroll, secretary-treasurer, is in charge of the office. F. W. Allen is chief engineer and D. Bonner and W. Kauffman are construction engineers. Joseph T. Rice is superintendent for Section 11 and E. Berglund for Section 12. Harry W. Redwood is superintendent of the tunnels being driven under air pressure and Aubrey Curtis is rock-tunnel superintendent.

WITHIN A TRENCH

This picture shows details of the method of placing the timber-wall supports behind the vertical H-beams. In the left foreground the setback usually provided appears about half way up, with the risers from the well points emerging from behind it. Farther along the trench the conditions were such that no setback was made and the drainage pipes were run their full length outside the timbers. This view also illustrates the method of bracing the walls at two levels. At this location the lowest of the two lines of cross supports was 16 feet from the trench bottom. This type of trench support is comparatively new.



VIEWS OF EQUIPMENT

One of the air-motor agitators is shown at the left. Note the small size of the motor mounted on top of the shaft. The top of another agitator unit, with the air hose connected to it, can be seen projecting from the tank ready for use. In the picture below is one of the portable pumping units, consisting of an air motor connected by chain drive to a Cam-Pump. Sections of flexible metal hose are attached to both the intake and the discharge of the pump to facilitate the making of connections.

Air Motors Promote Safety in a Paint Factory

THE photographs on this page illustrate two interesting uses of compressed air in a factory where special conditions must be met. In this instance, air motors are being employed to actuate agitators and to operate pumps in connection with the handling of highly inflammable liquids. They were selected primarily because they are a safety measure and also because they possess operating characteristics that are of value in the work the motors are called upon to do. They are installed in the plant of Aluminum Industries, Inc., Cincinnati, Ohio, manufacturer of Permite aluminum paint. This company is one of the country's largest producers of ready-mixed aluminum paints, varnishes, lacquers, and synthetic resins for commercial and industrial application.

Six air-motor agitators are in use in this plant for agitating resin mixtures and other fluids required in the making of its various products. These motors are of the standard Ingersoll-Rand multi-vane type having a rated speed of 450 rpm. that is varied by means of a throttle valve and in accordance with the amount of liquid being agitated. Each motor is direct connected to a ⅝-inch aluminum shaft at the other end of which are fixed two 3-blade aluminum impellers with a diameter of 7 inches. The shafts are of either 35- or 44-inch length.

For the pumping operations, three identical portable units are provided. Each consists of an Ingersoll-Rand multi-vane air motor connected by chain drive to a rotary-type Cameron pump which is known as the Cam-Pump. The air motor is governed at a speed of 3,000 rpm., and this is reduced in the transmission of power by a 9-tooth chain sprocket on the motor and a 20-tooth one on the pump. These units are used to transfer hot synthetic resins and varnishes from cooking kettles to storage tanks; to handle solvents or thinners; and they also act as circulating pumps in thoroughly mixing the resins and thinners while they are in storage tanks.

Each pump inlet is fitted with a strainer; and, to facilitate making connections, both inlet and discharge are fitted with 3-foot sections of flexible 1½-inch metal hose. These are either coupled to circulating pipes in storage tanks or fitted with additional lengths of flexible suction and discharge hose.

The average rate of pumping is 40 gpm., but this varies with the viscosity of the liquids handled and with the lift and head. Because it is possible to throttle down the air-motor driver, safer and more positive control can be exercised over the flow of solvents when they are being mixed with hot resins.

The Cam-Pump is especially well adapted for this sort of work, as it will handle either volatile or viscous liquids satisfactorily. Its action is more like that of a piston pump than of a centrifugal pump, with the added advantage that its flow does not pulsate as does that of a piston pump. It is a positive-displacement-type pump, the effect being that of pushing the liquid forward, just as is the case with the piston pump.

The pumping action is obtained through the rotation of two cam-shaped rotors mounted on parallel axes within a double-barreled chamber. The rotors turn in opposite directions, and with every revolution each one traps a part of the incoming liquid between itself and the wall of the chamber, moving it around and out through the discharge opening. While the rotors do not come in actual contact with each other, clearances are so small that a liquid seal is formed between them when they are in operation. A mechanical seal on the shaft prevents leakage of the fluid from the pump chamber.

Compressed air for operating the three pumping units and six agitators is furnished by a 9x8 ER-1 compressor.

SAFETY RECORDS

A CONSPICUOUS and encouraging trend in industry is the reduction in the frequency and the severity of accidents. Today's greatest toll of life and limb is taken not in shops and on construction jobs but on the highways and beaches. Men apparently have different standards of safety for work and for play. The explanation is to be found, of course, in the discipline that prevails where persons are employed. From Monday to Saturday, a breach of an established rule may bring discharge, so workers don't take chances. When the weekend comes, however, even the most cautious workman may venture to pass another car on a curve.

In certain industries, notably machinery manufacturing and nonferrous-metal trades, the frequency of accidents rose last year. Perhaps this was because the pick-up in employment put inexperienced men to work. These industries are fundamentally more hazardous than is the average one because of the great amount of machine work that is involved. In the sheet-metal industry, for instance, more than half the 1935 injuries were incurred by men tending presses. In some cases the employers were at fault for not sufficiently guarding the machines, but in the majority of mishaps the victims were careless.

Curiously enough, workmen that have been on a particular job a long time are very often the ones that get hurt. After a man has done one thing for a number of years he frequently takes unnecessary chances, believing that his familiarity with the operation will protect him.

There is still plenty of room for improvement of the accident record in the construction field. In 1935 it ranked twenty-seventh in frequency and twenty-ninth in severity among the major industries. The low standing was chiefly attributable to the poor comparative record for two types of accidents: those caused by men falling and those caused by objects falling.

Incidentally, as an example of what can be done, safety authorities are citing the record of a French company that has been digging up and destroying unexploded World War shells for eighteen years. It has handled 1,617,000 tons of projectiles without losing a man!

A PAYING INVESTMENT

THE United States purchased Alaska from Russia on March 30, 1867, for $7,200,000. Since then that territory has produced minerals valued at $698,628,000, or a little more than 97 times the price paid for it. If we add to the mineral yield the output of the salmon fisheries, sealing grounds, and other sources of revenue, it will be readily apparent that Uncle Sam struck a great bargain when he acquired the 590,884 square miles that constitute this northland empire.

Alaska's 1935 mineral production was valued at $18,312,000, or $1,591,000 more than in 1934. The gold output shrank $67,000, but amounted to the respectable sum of $15,940,000, or 87 per cent of the total of all the minerals. The principal increase was in copper, the comparative figures being $1,249,700 in 1935 and only $9,700 in 1934. The resumption of operations by large mines that had lain idle for three years explains the gain. For the same reason, silver, which is largely a by-product of copper, rose from $100,000 to $206,000. A surprising feature of the gold output is that placers still account for 61 per cent of the total, although intensive mining has been going on for nearly 40 years. The principal lode production comes from low-grade deposits in southeastern Alaska.

One of the gratifying points with respect to Alaskan mineral resources is their diversity. Platinum, mostly from placers, showed a goodly increase for the year, and considerable tin came from the same source. The other important metal is lead, of which about 800 tons was produced last year. Among nonmetallic minerals, Alaska possesses coal, limestone, and marble in commercial quantities.

MENTOR OF MILLIONS

ON THE first day of the present month, a group of distinguished men from various walks of life gathered at Miami University in Oxford, Ohio, to pay homage to the memory of William Holmes McGuffey, who was probably the most influential teacher of children this country has ever had. It was just 100 years ago that Doctor McGuffey produced the first of his Eclectic Readers for elementary school pupils. Subsequently, 122,000,000 copies of those readers were sold—a mark that has never been approached by any book in English save the Bible.

McGuffey's Readers were used by schools in 37 states, and served, more than any other instrumentality, as a guide in the moral and cultural education of the rising generation of those times. They contained selections from the classics, and proverbs, fables, mythology, bits of philosophy, and poems. Where he considered it necessary to simplify them for adolescent consumption, Doctor McGuffey rewrote them.

A native of Pennsylvania and the son of an Indian fighter, McGuffey was reared in Ohio, and remained there to become professor of mental philosophy and philology at Miami University. Later he was a member of the faculty of the University of Virginia. His direct teaching work was all concerned with college students, yet he was the indirect teacher of almost every child in the country for a period of more than twenty years. A McGuffey memorial shaft, designed by Lorado Taft, is to be erected on the Miami University campus. It will be surmounted by a bust of the educator, looking down upon three children grouped about a book. It was suggested by an engraving in the second McGuffey Reader.

Henry Ford has had some of the readers reprinted, believing that they could be read with advantage by children of today. With a view to popularizing them again, an editorial board of writers, college presidents and state governors is to compile material from the readers for the publication of a memorial volume.

Industrial Notes

Frozen and rusted connections that cannot be started in the usual way can, it is said, be loosened by an application of Pen-A-Trate, a new compound that is being marketed by Grapho Products, Incorporated.

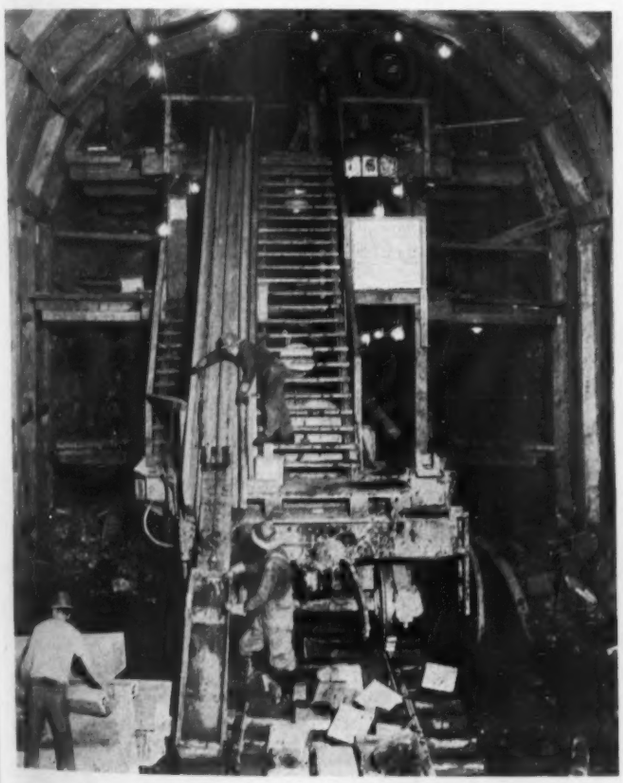
It is reported that powdered aluminum added to tar and bituminous compounds for highway use will not only give a high reflecting surface and thereby promote safer night driving but will also lower the temperature and prevent softening of the top course in hot weather.

E. F. Houghton & Company, has started a new publication, *Research, Illustrated*, that contains detailed information on processes in which its products are used rather than on the products themselves. The first issue was devoted to textile processing; and others that are in preparation will treat of transmission, lubrication, and metalworking. Technical problems are discussed from a research viewpoint, and are illustrated with reproductions of photographs and microphotographs. Men in industry may secure the publication by writing the company at 240 W. Somerset Street, Philadelphia, Pa.

The Twelfth National Exposition of Power and Mechanical Engineering—the Power Show, as it is now generally known—will be held during the week of November 30 at the Grand Central Palace, New York City, under the management of the International Exposition Company.

A new paint remover in paste form has been put on the market by Nielco Products Company and is said to loosen any kind of paint, varnish, or lacquer from any surface without injury to it or to skin and clothing. The compound has to be kept moist after application and is washed off, together with the paint, after it has done its work.

To prevent ladders from slipping, the American Allsafe Company is offering a self-aligning shoe which is said to provide a firm footing in soft and uneven ground and to assure nonskid contact with steel, wood, concrete, and other floor surfaces even when they are wet, oily, or covered with a film of ice. It is built of aluminum alloy with carborundum grit cast into the shoe plate to increase the hold, and with a stop that prevents placing the ladder at an unsafe angle. It is attached to the ladder rails by means of a saddle held in position by four bolts.



Photos Courtesy of Construction Methods

HUGE DRILL CARRIAGE USED AT PARKER DAM

Here are two views of a drill carriage that rivals in size those that proved so effective in driving the diversion tunnels at Boulder Dam. The one shown was used by J. F. Shea Company, subcontractor under Six Companies Inc., in drilling the 30-foot-diameter twin diversion tunnels at Parker Dam on the Colorado River.

This rig was mounted on the chassis of an old power shovel and was shifted back and forth on standard-gauge track by an electric locomotive. It had wooden platforms at three levels, with folding side extensions. By collapsing these wings the carriage could be reduced to a width of 15 feet to facilitate moving. It was 22 feet high. The raising and lowering of the wings was done by a Size HU "Utility" air hoist, which was also employed for elevating drill steel and timbers to the top platform.

The carriage was designed for mounting twenty-four N-75 Auto-Feed drifter drills. Not more than one-third of these were operated at a time; but as the contractor had that number on hand, it was considered a more effective plan to use all of them. With that many spares available, the shift boss could line up drills for each drill runner in advance, which meant that there were no delays between the finishing of one hole and the starting of another.

In the right-hand picture the carriage is seen in course of construction. It will be noticed that horizontal bars were provided at six levels. These were of 4-inch, extra-heavy pipe. Swivels on the outer vertical columns permitted swinging the projecting ends of these horizontal bars back parallel with the sides to assist in moving the rig.

Six to eight drill runners worked on the carriage, depending upon the number of holes to be placed. These ranged from 80 to 110 per round, and were drilled 10 feet deep. The time of drilling a round varied from 2 to 3½ hours. As all the drifters were mounted in the same vertical plane, the holes were ended in the same plane. This produced a desirable shear of the rock and left a square face for the following round.

M. S. Boss was general superintendent for J. F. Shea Company on this job.

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